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Experimental Study On Concrete With Partial Replacement Of Fine Aggregate With Crushed 4th Class Bricks With Addition Of Glass Fibre

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ABSTRACT

This experimental study investigates the viability and performance of concrete mixtures with recycled crushed fourth class bricks as a partial replacement for fine aggregate, while also enhancing its properties with the addition of glass fiber, as the construction industry seeks sustainable and innovative solutions. The goal of this study is to improve the mechanical properties of concrete while also lowering the environmental effect of building materials.
This research included the preparation of several concrete mixes, each with a different proportion of crushed fourth class bricks and an addition of glass fiber to improve the concrete's mechanical qualities. We put various concrete mixtures through their paces to see how they fared in terms of compressive strength, tensile strength, flexural strength, workability, and durability. Regular concrete was used as a control to see how the results stacked up.
This study demonstrates the feasibility of using crushed fourth-class bricks and glass fiber to produce sustainable, high-performance concrete mixes. While the inclusion of glass fiber enhanced the concrete's mechanical qualities, replacing some of the fine aggregate with broken bricks showed encouraging outcomes in terms of sustainability. Additional research is necessary to determine the ideal percentages of each ingredient and the types of fibers to use.
This research provides useful information on using recycled resources and high-tech additives in concrete manufacturing, and it adds to the increasing body of knowledge on environmentally friendly building materials. These results show potential for improving the performance of concrete buildings while lowering their environmental effect.

Keywords: Glass fibre, Fourth class bricks, Compressive strength, Split tensile, Flexural Strength.

I. INTRODUCTION

1.1 Concrete

Concrete is an excellent structural material. Made by combining cement, water, and both tiny and large pebbles of varying sizes. Its versatility and adaptability have led to widespread use as a construction material. Unlike materials like natural stone or steel, which must be used in their unaltered forms, concrete may be modified to better suit the intended purpose. This is a wonderful thing: when you press on it, it's powerful, but when you take it apart, it's weak. Adding steel rebars into the concrete is a common practice, leading to the term "reinforced concrete."

Numerous structures, ranging from modest homes to massive skyscrapers, make use of concrete. Though reliable and secure, not everyone has mastered its proper use. To fill this need, we provide Concrete Fundamentals. Everything from what materials to use to the best methods for planning, constructing, finishing, and maintaining your house are all detailed here.

If you're not an expert but would still want to tackle concrete tasks like house repairs or light building, Concrete Basics is for you. It also assists folks who observe over building work but aren't specialists themselves. The objective is to make the technical material accessible by providing straightforward explanations and visual aids. So, whether you're doing something simple at home or working on a major project, Concrete Basics can help you build excellent concrete.

Learning these terms may help construction professionals communicate more effectively. Better communication and understanding between construction workers, builders, engineers, building inspectors, architects, and anyone else interested in the process of creating high-quality concrete is one of the many benefits of Concrete Basics.

Concrete has become a sturdy and stable material for numerous purposes throughout time. It has a stellar reputation for durability, fire resistance, ease of maintenance, energy efficiency, and environmental friendliness. Concrete has more uses than any other man-made substance on Earth because of its many benefits.

Depending on the proportions of cement, sand, pebbles, and water, we may create a substance known as concrete. In different concentrations, these factors affect how concrete performs.

In many parts of the globe, concrete is the material of choice for construction. We are learning more sophisticated methods of using it in building projects.

We are rapidly depleting natural resources, thus we must develop alternative materials to employ in construction. For example, fine sand is becoming more scarce and costly. As an alternative to utilizing fine sand, we are considering using broken bricks in concrete.

Concrete can withstand considerable force when pushed, yet it breaks easily when bent. The standard fix involves expensive steel bars to reinforce the structure. People from all walks of life are experimenting with new additives for concrete in an effort to make it more durable and affordable. Glass fibers are one additive that may make concrete stronger and more durable.

Cement concrete strengthened with glass fiber reinforcement. Glass fiber consists of very fine glass strands. It's almost as strong as carbon fiber but cheaper and more durable when combined with other fibers.

As a result of rapid economic development, India is undergoing a construction boom. It is becoming increasingly difficult and costly to get the materials required for construction. We reasoned thusly. We may use crushed fourth-class bricks, which are abundant and inexpensive, in place of sand. This may increase the durability and longevity of the concrete.

In order to verify our theory, we decided to look into it thoroughly. We want to demonstrate that low-cost crushed fourth-class bricks, combined with glass fiber, may replace sand in the production of durable concrete.

We conduct a battery of experiments on glass-fiber-reinforced concrete blocks that also have broken fourth-class bricks as a partial sand replacement..

- Ease of use
- Strength under compression
- Strength under tension across a split
- Strength when subjected to bending

II. LITERATURE REVIEW

1. **S. Keerthinarayana and R. Srinivasan performed a research using crushed waste fire bricks as a replacement for some of the fine** aggregate in concrete. This is what they discovered:When they substituted 25% of the FA with crushed waste fire brick, the concrete had the maximum compressive strength. This concrete's strength was actually marginally higher than that of fine-aggregate concrete.

   They also discovered that the split tensile strength and flexural strength of the concrete containing crushed waste fire brick were greater than those of regular concrete.

   The study's findings led the authors to the conclusion that broken-down refractory bricks may stand in for traditional, water-sand aggregates for making concrete. This implies it may be an excellent option to make concrete stronger and more durable.

2. **Md. Abid Alam, et.al** did research on glass-fiber-reinforced concrete. What they found is as follows:
   By altering the texture and behavior of the concrete, fiber reinforcement might be a hindrance to its usage.
   When they increased the fiber content, the concrete became more resistant to crushing. Fibrous reinforcement greatly improved the concrete's resistance to cracking under tension.
   The concrete's resistance to compression (when you push on it) did increase somewhat, but the greater strength came from its resistance to tension (when you pull on it).

   3. In their concrete study, **K. Praveen, et.al** used reclaimed bricks from demolition as coarse aggregates and mixed with micro-silica for targeted outcomes.
   The quality of the concrete you produce will improve with careful inspection of the bricks you utilize. By substituting 10% micro-silica for portion of the cement in a certain kind of concrete mix, the resulting material is much more durable. Micro-silica is essentially a specific component that helps the concrete hold together better. Additionally, micro-silica eliminates voids in the concrete, increasing its strength and durability. They discovered a more efficient method of construction by combining micro-silica with recycled, over-burned bricks. It's beneficial to the planet since it reduces the need for raw materials like cement and rock.

4. **George Rowland Otoko** Used crushed clay bricks to make road asphalt was the topic of investigation. This is what they discovered:
   Crushed clay bricks made a better road surface than normal granite pebbles. The clay bricks' rough and holey surface better adhered to the asphalt, leading to this effect. Recycling bricks may have environmental benefits when used in road construction. Because of the lower density of these bricks, roads constructed with them weigh less. Less effort is required to mix and lay down the road as a result. When it comes to the road's durability, it doesn't matter what kind of rocks they utilized. How pitted, jagged, and sharp the rocks were was more important. Crushing fresh or old clay bricks and using them to pave roads is a fantastic concept that turns out to be effective.

5. **Gopinandan Dey and Joyanta Pa**l test the impact of utilizing crushed bricks in normal concrete on the material's thermal stability. This is what they discovered:If you utilize 35%-40% of the cement as water, the concrete you build from broken bricks will be just as strong as any other sort.
6. They added a superplasticizer to the concrete to make it more manageable. Weirdest part? izer to the cement... Adding.... of...
7. In addition, the concrete's strength was always at least up to code, and often beyond it.You don't need to soak the bricks or add a ton of water to the concrete mix to get it to stick together. If you let them 3 minutes to drink, you'll know exactly how much water to give them.Surprisingly, the concrete behaved even better after 2 hours of exposure at 600 degrees Celsius than it did at room temperature.

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III. OBJECTIVES

Study Strength: The primary goal of this research was to determine how much improvement there was in the compressive strength, tensile strength, and bending strength of concrete after curing for 7 and 28 days.

Compare Strength: The purpose of this research is to compare and contrast the average CS of conventional concrete with that of concrete in which sand is partially replaced by fourth-class bricks (at varying percentages between 0% and 20%) and 1% glass fiber is also included.

Assess Tensile Strength: White stone has an average tensile strength (IV) for splitting. To evaluate the effectiveness of sand as a partial replacement for stone, we will use grade bricks (0, 5, 10, 15, and 20%) and fiberglass (1%) as our units of measurement.

Evaluate Flexural Strength: The purpose of this study is to compare the average flexural strength of conventional concrete to that of concrete with a partial sand replacement using fourth-class bricks (from 0% to 20%).

Brick Replacement: Examining whether or not brick dust may function as a suitable replacement for sand in concrete mixes.

Waste Management: Use of discarded fourth-class bricks in concrete may help with waste minimization and lead to more effective trash management.

Cement and sand will undergo rigorous testing as part of the experimental program to determine their physical properties. Standard procedures include: sieve analysis, cube compressive strength, normal consistency, initial setting time, and final setting time.

IV. TESTS CONDUCTED

4.1 Compressive Strength Test:

They employed a universal testing machine (UTM) with a capacity of 2000 kilonewtons (KN) to determine the strength of the concrete cubes. The purpose of this apparatus is to apply a certain force to different materials in order to determine how sturdy they are.

Compressive strength test

It is possible to determine how much force a material can withstand before breaking using a mechanical test. Compression testing is progressively compressing a sample, often a cube, between two flat surfaces. Slowly increasing the force causes the material to get squeezed, which leads to cracking and finally breaking. Its compressive strength is the highest amount of pressure it can take before cracking.

Fig 1: Compression testing machine

4.2 Split Tensile Test

This is the gold standard for determining concrete's tensile strength indirectly. In other words, it conforms to the standards set out in IS: 5816-1970. A brief summary of the examination is as follows:

Arrangement for Testing: You'll need to begin with a regular concrete cylinder. It is a cylinder with a length of 300 mm and a width of 150 mm. Placed horizontally between the two flat surfaces of a Compression Testing Machine, this concrete cylinder will undergo compression testing. Start the Program: Compression: You apply the load, the cylinder, the compression. This force is delivered equally and diametrically, which means it's pushing on the cylinder from both sides, compressing it.

Although we are compressing the concrete in this test, we may infer its tensile strength and hence assess how well it can endure a pulling apart. The data are important in construction to verify the concrete used satisfies the requisite strength criteria.

Fig 2: Split tensile testing machine

4.3 Flexural Strength Test

We're trying to bend a standard-sized concrete beam to gauge its strength. The beam's dimensions are typical, not excessive: 10 cm in width, 10 cm in thickness, and 50 cm in length.

Fig 3: Flexural testing machine

V. EXPERIMENTAL PROGRAMME

Binding ingredients, tiny pebbles, large boulders, and water all come together to form concrete. But before we start mixing cement, it's crucial that we learn the following:
Properties of Cement: We need to know specifics about the cement we're using, such as its fineness, its mixing thickness, and its beginning and ultimate setting times. We also make sure to weigh everything.
Concrete requires fine aggregate, which is the smallest particles. We're curious in its fineness, density, and storage requirements.
Larger rocks in the mixture make up the coarse aggregates. We measure the density, fineness, and weight of the specimens.
With this information in hand, we can produce high-quality concrete that will stand the test of time in a variety of building applications..

5.1 Materials

5.1.1 Cement

Coromandel King Ordinary Portland Cement (43 Grade) is the cement type recommended for the whole project. There are a few things you should know before using this cement:
This cement has a strength level known as "43 grade," which indicates the maximum force it can withstand before cracking. It's a gauge of its sturdiness and durability.
Manufacturer: Coromandel King is the brand behind this product.
The cement you're using is all from the same batch, so its qualities shouldn't vary much from place to place. Your work will be more consistent and trustworthy if you do this.
How soon the cement will harden after being combined with water is indicated by the setting time.
How effective and durable your concrete ends up being depends on how tiny the cement particles are.
Ingredients: Knowing the cement's constituent parts, such as silica or alumina, may help ensure its quality.
Cement's density per unit volume is an important factor in making precise volumetric measurements.
The consistency of the cement paste may determine how easy it is to work with, so knowing whether it is too thick or too watery is important.
Density is an indicator of how tightly packed the cement particles are. As they set, certain cements release heat. When dealing with a large quantity of cement, this knowledge is invaluable.

Table 1: Properties of cement

Sl. No	Properties	Results
1.	SG	3.1
2.	NRC	32%
3.	IST	35min
4.	FST	480min

5.1.2 Fine Aggregate:

- Good grade sand, like granules that would pass through a fine screen, is what we're utilizing.
- Clean Sand: This sand is very clean since it washes up from neighboring rivers. Without salt, there is nothing nasty. There are no organic or toxic ingredients either.
- Monitoring Moisture: We must monitor the level of moisture in the sand. Depending on this, we may or may not need to add more water to the concrete mixture.

We're utilizing excellent sand from nearby rivers in our concrete mixes and paying attention to how moist the sand is. This ensures the quality of our concrete.

Table 2: Properties of fine aggregate

Properties	Result
SG	2.7
BD (compacted condition)	1914 Kg/m^3
BD (Loose condition)	1476 Kg/m^3
FM	2.8 %

5.1.3 Coarse aggregate

We're using crushed rocks that are bigger than 20 millimeters and some smaller onestoo. These rocks come from a local crushing plant.

Table 3: Properties of Coarse aggregate

SG C.A	2.87	CS	13.96 %
FM	3.98 %	AV	8.7 %
BD	1615 kg/m3	IS	9.16 %
FI	15.21 %	EI	28.26 %

5.1.4 Glass fibre

- Buddha Building Technology in Thane is where we purchased the glass fibers.
- Each of these strands is 12 millimeters in length.

5.1.5 Water

We're going to use regular tap water for mixing and curing during the investigation.

5.1.6 Crushed fourth class brick

The crushed fourth-class brick is made up of these things:

- Sand (Silica) - Makes up about 50% to 60% of the weight.
- Clay (Alumina) - Makes up around 20% to 30% of the weight.
- Lime - About 2% to 5% of the weight.
- Iron Oxide - Less than or equal to 7% of the weight.
- Magnesia - Less than 1% of the weight.

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VI. EXPERIMENTAL INVESTIGATION

6.1 Preparation of test specimen

We performed a slump test to see how workable the concrete was after mixing it by hand.
We constructed three kinds of concrete samples: cubes, cylinders, and beams.
After 24 hours, we withdrew these samples from their molds and placed them in water for 3, 7, and 28 days to assist them develop strong.
We pulled some of these samples out of the water on days 3, 7, and 28 to assess how robust they had gotten.
We put them through a battery of tests including compression, tension, and bending to see how they hold up.
This helps us comprehend how concrete grows stronger as it rests in water and cures.

Fig 4: Casting of Specimen

Fig 5: Curing of Specimens

6.2 Testing of specimens

- In our study, we used cubes, cylinders, and prisms as test specimens.
- Each cube has identical dimensions of 150mm on each side. The cylinders are around 300mm in depth and 150mm in diameter. Prisms measure 500 millimeters in length, 150 millimeters in width, and 150 millimeters in height.
- For the sake of uniformity, we measured and prepared all the test specimens to be the same size.

Fig 6: Testing of Cube


Fig 7: Testing of Cylinder


Fig 8: Testing of Prism

VII. RESULTS AND DISCUSSION

7.1 Compressive strength

The specimens used in the compression tests were 150mm cubes, and there were a total of 30 of them. The table below displays the outcomes of these analyses. The table values are averages based on three separate tests.

The formula for calculating the compressive strength (CS) of a cube is as follows: Compressive Strength (CS) = Maximum Load on Cube (W) divided by the Effective Area (A), where W is the weight of the cube and A is the area.

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7.2 Split tensile strength:

Thirty regular concrete cylinders served as test subjects. These cylindrical objects are 150mm in diameter and 300mm in depth. The table below displays the outcomes of these analyses.
To calculate the split tensile strength (ft) of each cylinder, we used the following formula:
Split Tensile Strength (ft) = Maximum Load on Cylinder (W) divided by the product of the Length of the Cylinder (L) and its Diameter (D).

7.3 Flexural strength:

We tested a total of 30 beams, each measuring 150mm by 150mm by 500mm.

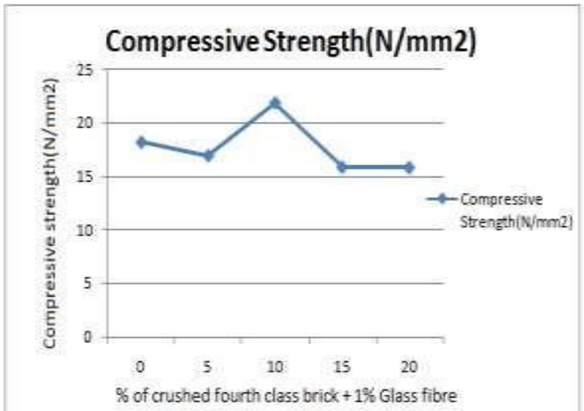
During these tests, all the specimens broke within the middle 3rd of the beam.To calculate the FS (f) of each beam, we used the following formula:
Flexural Strength (f) = Maximum Load on the Prism (W) divided by the product ofthe Length of the Prism (L), Width of the Prism (B), and the square of the Depth of the Prism (D).

Table 4: Results of CS(N/mm^2)for cubes

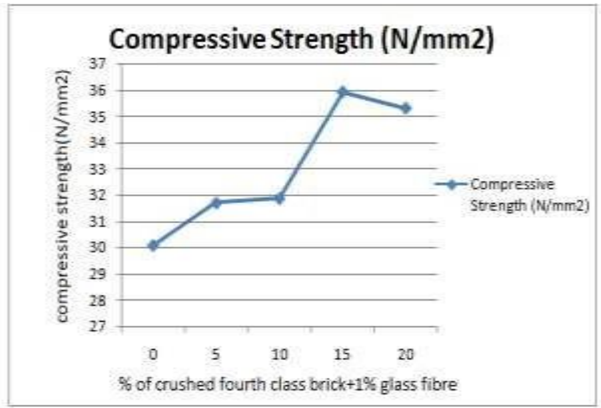
% of C-4B	%GF	7Days (1 week) (N/mm^2)	28Days (4 week) (N/mm^2)
0	0	18.2	30.07
5	1	16.94	31.69
10	1	21.86	31.86
15	1	15.87	35.93
20	1	15.83	35.31

Line Chart

After 7 and 28 days of cure, we measured the CS of the cubes. It featured a wide range of percentages ranging from 80% to 200%. In all of these mixes, we maintained the proportion of glass fiber constant at 1%.



7 days



28 days

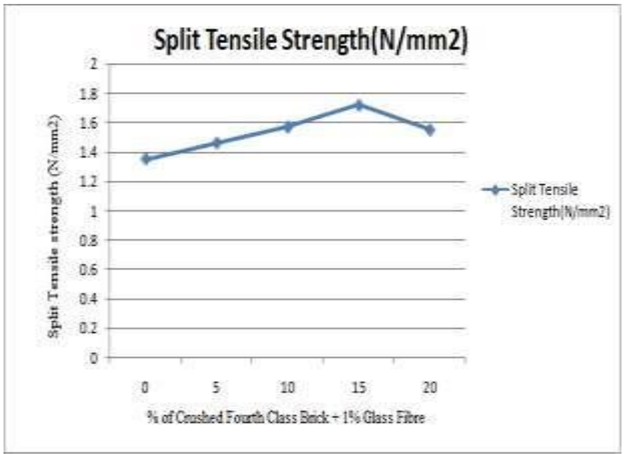
Graph 1: Compressive strength (N/ mm2) of cube at the rate of 7 and 28 days

Table 5: Results of STS(N/mm^2)for cylinder

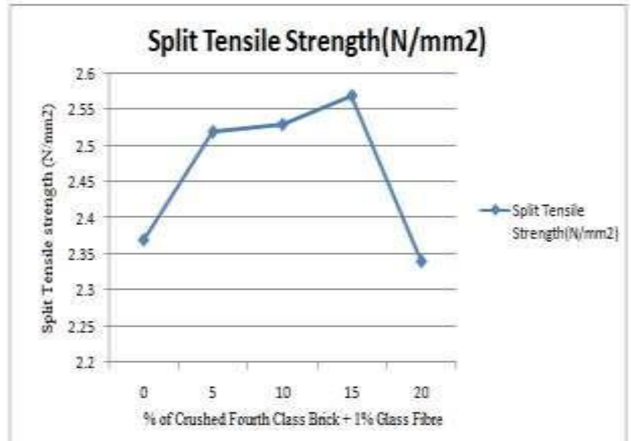
% of crushed fourth class brick	**% of Glass fibre**	**7 Days(1 week) (N/mm^2)**	**28 Days(4week)(N/mm^2)**
0	0	1.35	2.37
5	1	1.46	2.52
10	1	1.57	2.53
15	1	1.72	2.57
20	1	1.55	2.52

Line Chart

After 7 and 28 days of curing, we evaluated the STS of the cylinders. These rollers are employed diverse combinations that comprised variable proportions of crushed fourth-class bricks, ranging from 0% to 15%. In all of these mixes, we maintained the proportion of glass fiber constant at 1%.



7 Days



28 Days

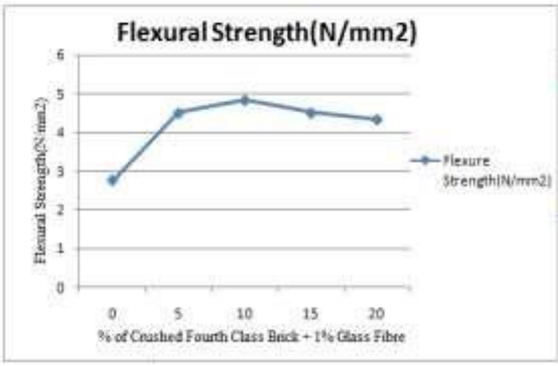
Graph 2: STS (N/mm2) of cylinder at the rate of 7days and 28days

Table 6: Results of FS(N/mm^2)for Prism

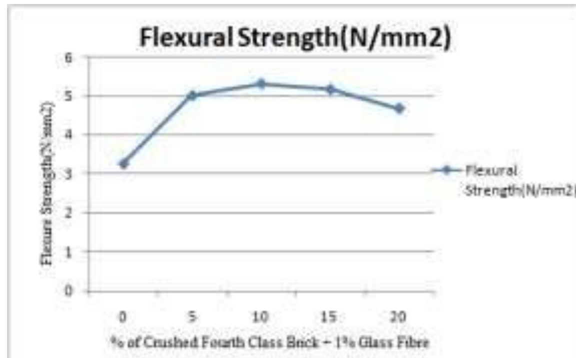
% of crushed fourth class brick	**%Glass fibre**	**7 Days(1week) (N/mm^2)**	**28 Days(4week)(N/mm^2)**
0	0	2.75	3.25
5	1	4.5	5
10	1	4.83	5.3
15	1	4.5	5.16
20	1	4.33	4.67

Line Chart

We measured the FS of prism-shaped specimens after 7 and 28 days of curing.This model is designed to be used different mixtures that had varying amounts of crushed fourth-class bricks, ranging from 0% to 20%. In all of these mixtures, we keptthe amount of glass fiber constant at 1%.



7Days

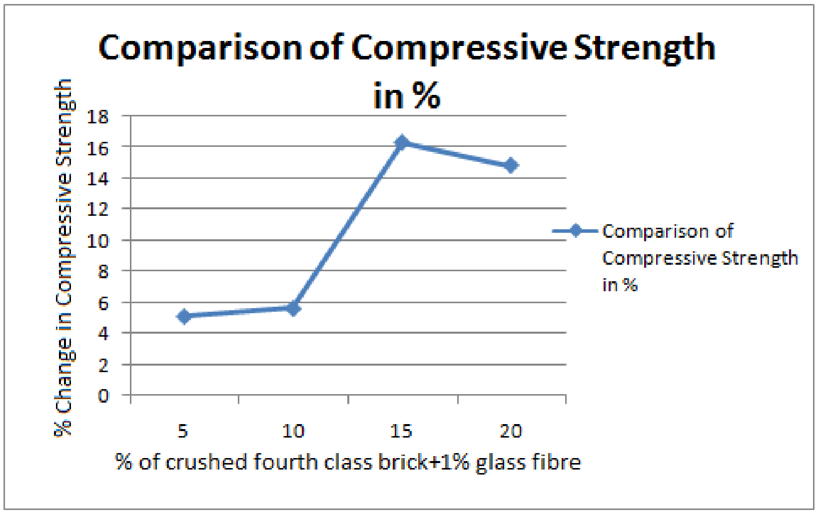


28 Days

Graph 3: Flexure strength(N/mm2) of prism at the rate of 7 and 28 days

Table 7: Comparison of CS of different mix w.r.t conventional concrete

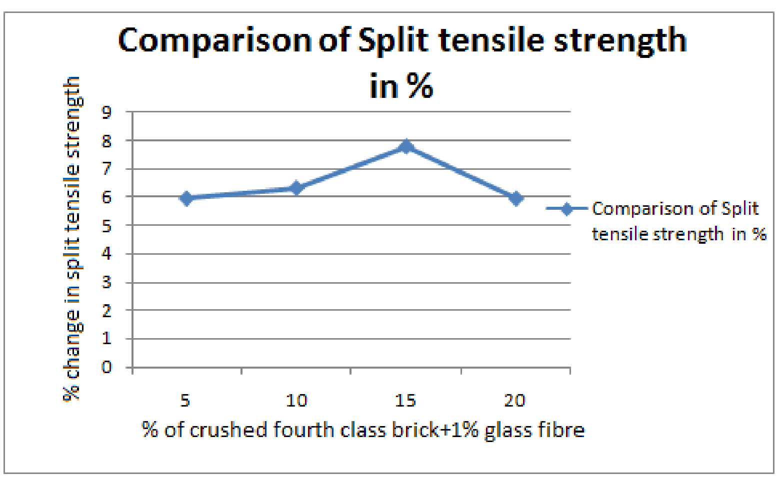
Sl. no	**% of C-4B**	**% of GF**	**% increase in compressive strength w.r.t 0% for 28 days**
1.	5	1	5.11
2.	10	1	5.62
3.	15	1	16.31
4.	20	1	14.84



Graph 4 Line chart for change in CS for 28 days w.r.t 0%

Table 8: Comparison of STS of different mix w.r.t conventional concrete

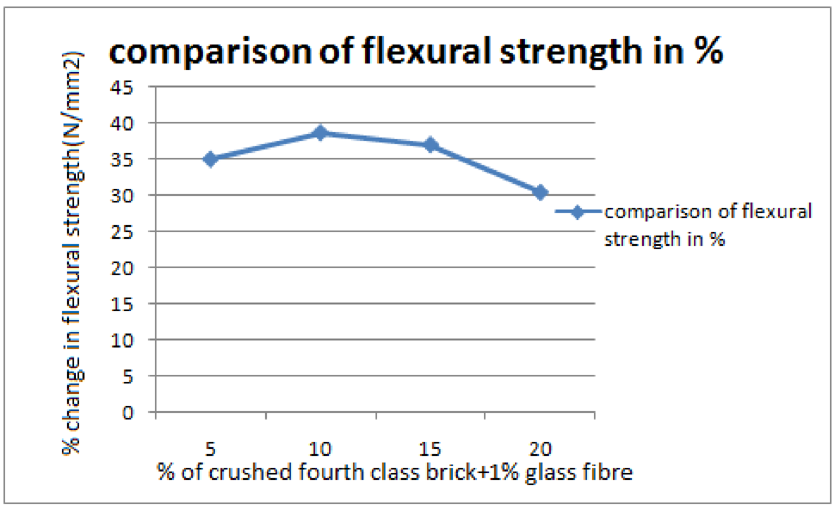
Sl. no	% of crushed fourth class brick	% of glass fibre	% increase in split tensile strength w.r.t 0% for 28 days
1.	5	1	5.95
2.	10	1	6.32
3.	15	1	7.78
4.	20	1	5.95



Graph 5: Line chart for change in STS for 28 days w.r.t 0%

Table 9: Comparison of FS of different mix w.r.t conventional concrete

Sl. No	% of crushed fourth class brick	%of glass fibre	%increase in flexural strength w.r.t 0% for 28 days
1.	5	1	35
2.	10	1	38.67
3.	15	1	37.02
4.	20	1	30.41



Graph 6: Line chart for change in flexural strength for 28 days w.r.t 0%

VIII. CONCLUSION

- The average compressive strength of regular concrete is 30.07 N/mm^2.
- The average split tensile strength of regular concrete is 2.37 N/mm^2.
- The average flexural strength of regular concrete is 3.25 N/mm^2.
- In comparison to standard concrete's values of 30.07 N/mm^2, 2.37 N/mm2, and 3.25 N/mm^2, the concrete made by replacing 15% of the fine aggregate with crushed fourth-class bricks and adding 1% glass fiber has a compressive strength of 35.93 N/mm^2, a split tensile strength of 2.57 N/mm^2, and a flexural strength of 5.16 N/mm^2.
- By exchanging 15% of the fine aggregate for crushed fourth-class bricks, we are able to boost both the split tensile and flexural strengths by 7.78% and 37.02%, respectively.

- Adding Fiberglass and replacing normal sand with crushed fourth-class bricks not only boosts the strength of concrete, but also its durability, possibly elongating the lifetime of constructions.

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