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# Experimental Investigations On Fiber Reinforced Concrete For Sustainable Construction

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**Abstract:**

: The use of fibers to strengthen tension-weak matrices dates back over 4500 years. Since the rise of Portland cement concrete, fibers have been added to improve strength and prevent cracking, though progress in fiber reinforcement was slow until the 1960s. Typically, fibers like steel and glass are used to enhance concrete's durability and crack resistance. This project evaluates the compressive strength of aramid fiber-reinforced concrete at 3, 7, and 28 days, comparing it to regular and other fiber-reinforced concretes (M20 grade). While steel fibers offer the highest strength, glass fibers resist cracking, and aramid fibers provide strength and crack resistance. Fiber-reinforced concrete is now widely used in slabs, shotcrete, panels, precast items, seismic structures, repairs, and more. This study highlights aramid fibers' integration, particularly in innovative concrete applications.

***Keyword***: Aramid fibers, fiber-reinforced concrete, split tensile strength, ductility, flexural strength, toughness, and workability.

## 1. Introduction

### Fiber Reinforced Concrete (FRC): Applications, Properties, and Advantages

Fiber Reinforced Concrete (FRC) is a specialized form of concrete that incorporates fibrous materials into the cement matrix to improve its overall structural integrity and performance. The use of fibers in concrete has grown rapidly across various fields, finding applications in construction projects that demand enhanced durability, toughness, and crack resistance. The versatility and effectiveness of FRC make it a valuable option in construction, competing economically with traditional reinforcing systems and offering distinct advantages in terms of material properties.

Fiber Reinforced Concrete is created by adding different types of fibers, such as steel, glass, polypropylene, or aramid, into a cement matrix. The fibers serve to increase tensile strength and enhance the toughness of the composite, thereby improving its performance under loads that would typically cause cracking or deformation. FRC is highly effective in applications where there is a need for superior crack control and resistance to impact, fatigue, and tensile forces.

The primary objective of incorporating fibers into concrete is to achieve a material that not only resists cracking but also distributes any potential cracks more uniformly. This distribution of cracks results in a reduction of crack width, effectively improving the durability and aesthetics of concrete structures.

A crucial parameter that defines the effectiveness of fibers in concrete is the aspect ratio. The aspect ratio of a fiber is calculated by dividing its length by its diameter. This ratio is significant because it influences the fiber's ability to bond with the cement matrix and its overall contribution to the concrete's structural properties. A higher aspect ratio generally leads to better performance in terms of tensile strength and toughness, but the optimal aspect ratio varies depending on the fiber type and intended application.

***Types of Fibers and Their Effects on FRC Properties***

Different fibers offer varied benefits to Fiber Reinforced Concrete, each contributing uniquely to the material's overall properties:

- **Steel Fibers**: Steel fibers are commonly used in FRC due to their high strength and ability to increase the tensile strength and impact resistance of concrete. Steel fiber-reinforced concrete is widely used in heavy-duty pavements, bridge decks, and industrial floors where high load-bearing capacity is essential.

- **Glass Fibers**: Glass fibers provide significant resistance to cracking and are often used in applications that prioritize aesthetics, such as architectural facades. However, glass fibers can be less durable under alkaline conditions, which may limit their use in certain environments.

- **Polypropylene Fibers**: Polypropylene fibers are lightweight and resist chemical degradation, making them suitable for reducing plastic shrinkage cracks in concrete. This fiber type is commonly used in applications like slab-on-grade floors, sidewalks, and driveways.

- **Aramid Fibers**: Aramid fibers, known for their high tensile strength and heat resistance, provide excellent compressive strength and crack resistance compared to other fiber types. This makes aramid fibers particularly useful in structures where both high load-bearing capacity and durability are required.

***1.4 Advantages of Fiber Reinforced Concrete***

The benefits of using Fiber Reinforced Concrete extend beyond just improved crack resistance. Key advantages include:

- Increased Toughness: FRC is significantly tougher than conventional concrete due to the energy absorption capabilities of the fibers. The fibers absorb energy from external forces, thus preventing rapid crack propagation.

- Enhanced Tensile Strength: Fibers improve the tensile properties of concrete, enabling it to withstand greater tensile stresses before cracking. This is crucial in applications like pavements and bridge decks where tensile forces can cause early failure in conventional concrete.

- Crack Control and Reduced Crack Width: One of the major benefits of FRC is its ability to control crack patterns. By dispersing cracks throughout the matrix, FRC reduces the width of cracks, leading to a more durable and aesthetically pleasing structure.

- Improved Fatigue Resistance: The fatigue resistance of FRC is higher than that of regular concrete, which makes it suitable for applications that are exposed to cyclic loading, such as highways and airport pavements.

***Factors Influencing FRC Properties***

The performance of Fiber Reinforced Concrete depends on several key factors:

- **Mechanical Properties of Fibers**: The type of fiber used, along with its tensile strength, elasticity, and durability, directly impacts the toughness, crack resistance, and fatigue performance of FRC.
- **Fiber-Matrix Bonding Properties**: The effectiveness of fibers in concrete is also dependent on their bonding properties with the cement matrix. A strong bond ensures that the fibers can effectively transmit stresses, helping to resist cracking.
- **Fiber Quantity and Distribution**: The amount and uniformity of fiber distribution in the matrix are critical to the overall performance of FRC. Optimal distribution allows for consistent crack control and increases the structural capacity of the composite.

For FRC to be widely adopted as a construction material, it must offer an economical advantage over traditional reinforcing methods. Although the initial cost of FRC may be higher due to the inclusion of fibers, its long-term benefits, such as reduced maintenance costs, longer service life, and enhanced durability, make it a cost-effective solution. In applications where high performance and reduced cracking are essential, FRC can significantly decrease the overall lifecycle costs of the structure.

## 2. Materials

### Materials Used in Fiber Reinforced Concrete (FRC) and Their Significance

Fiber Reinforced Concrete (FRC) is a specialized composite material made by integrating various fibers within a cement matrix, which gives the concrete superior strength, toughness, and crack resistance. Each component in FRC, from the type of cement to the choice of fibers, plays a crucial role in achieving the desired performance properties. The materials typically used in FRC, including Pozzolana Portland cement, coarse and fine aggregates, sand, superplasticizers, and different fiber types, are carefully selected to optimize structural strength, durability, and overall functionality in construction.

### 1. Cement: Pozzolana Portland Cement (53 Grade)

Cement is the primary binding agent in concrete, and its quality significantly influences the overall strength and durability of the composite. In FRC, Pozzolana Portland Cement (PPC) of 53 grade is commonly used due to its high compressive strength and durability. Pozzolana cement incorporates pozzolanic materials, which react with calcium hydroxide to form additional cementitious compounds, resulting in a denser, more durable matrix that enhances the concrete's performance against sulfate attacks and other environmental factors. The 53-grade cement refers to its high compressive strength of 53 MPa at 28 days, which ensures that the concrete can withstand heavy loads and maintain its integrity over time. This cement type also aids in improving the concrete's workability and reducing heat generated during curing, which is particularly beneficial in large structural applications where thermal cracking is a concern.

### 2. Coarse Aggregate (Size 20 mm)

Coarse aggregates are essential in FRC as they contribute to the concrete's bulk and compressive strength. Aggregates with a 20 mm size are ideal for creating a strong and stable matrix, as they provide a robust skeleton for the concrete mix. The use of appropriately sized coarse aggregates improves the load-bearing capacity of the concrete and reduces shrinkage. A well-graded aggregate mix also minimizes void spaces, which in turn lowers water demand and enhances the bonding within the matrix. In FRC, coarse aggregates must be strong and durable, ensuring that they can handle stress without causing deformation or fracturing. Their size and shape contribute to the distribution of fibers, allowing the fibers to embed properly within the matrix and improve crack resistance.

### 3. Fine Aggregate (Size 10 mm)

Fine aggregates, typically consisting of small-sized particles, are added to the concrete mix to fill gaps and provide a smooth, cohesive matrix. In FRC, fine aggregates of around 10 mm in size are used to ensure an even distribution of particles within the concrete, reducing the potential for voids and enhancing the mix's density. Fine aggregates work in conjunction with coarse aggregates to create a well-compacted matrix that prevents excessive shrinkage and cracking. They also aid in achieving a smooth finish, which is particularly important in structural applications that require a high-quality surface finish. Furthermore, the fine aggregate's size and shape can influence the flowability and pumpability of the concrete mix, making it easier to work with during placement.

**4. Sand (Less than 4.75 mm)**

Sand, with particle sizes of less than 4.75 mm, is a crucial component in FRC for improving the mixture's workability and reducing the void content. High-quality sand ensures that the concrete matrix is densely packed, providing increased strength and resistance to external stresses. The fine particles of sand fill small gaps between coarse and fine aggregates, contributing to a smooth, uniform mix. In FRC, sand also helps distribute fibers evenly throughout the matrix, which is essential for achieving effective crack control. The fine nature of sand particles improves bonding between the cement paste and aggregates, resulting in a denser and more durable final product. Properly graded sand minimizes shrinkage and enhances the dimensional stability of the concrete, which is crucial for applications requiring precise structural integrity.

**5. Admixture: Superplasticizers**

Superplasticizers are high-range water reducers added to the concrete mix to improve its workability without compromising its strength. In FRC, the use of superplasticizers is essential for achieving a workable mix with low water content, as fibers in the mix can make the concrete more challenging to work with. Superplasticizers allow for a reduction in water-cement ratio, which enhances the concrete's compressive strength and durability. These admixtures enable the concrete to flow easily, filling molds and covering reinforcements effectively, even in complex structural forms. By improving the dispersion of fibers in the matrix, superplasticizers contribute to better crack control, increased load-bearing capacity, and enhanced durability in the hardened concrete. They also prevent issues related to segregation and bleeding, ensuring a consistent and homogeneous mix that can be effectively compacted and finished.

**6. Fibers: Glass, Steel, and Aramid Fibers**

Fibers are the defining component in Fiber Reinforced Concrete, providing it with enhanced tensile strength, toughness, and crack resistance. The most commonly used fibers in FRC include glass, steel, and aramid fibers, each offering distinct benefits:

- **Glass Fibers**: Glass fibers are lightweight and provide good tensile strength and crack resistance. They are non-corrosive, making them suitable for environments exposed to moisture and chemicals. Glass fibers help prevent surface cracks and improve the concrete's aesthetic quality, making them ideal for decorative or architectural applications.

- **Steel Fibers**: Steel fibers are highly effective in enhancing the tensile and impact resistance of concrete, especially in applications that bear heavy loads or experience high traffic. Steel fibers prevent the propagation of cracks, allowing the concrete to handle high-stress conditions. They are commonly used in industrial floors, pavements, and structures requiring high durability.

- **Aramid Fibers**: Aramid fibers offer superior tensile strength, crack resistance, and compressive strength compared to glass and steel fibers. Known for their durability and resistance to high temperatures, aramid fibers are ideal for applications that require long-lasting, high-performance concrete. Their toughness and resilience make them suitable for structures exposed to extreme conditions.

**7. Water: Potable Water**

Water plays a critical role in the hydration process of cement, contributing to the strength and workability of the concrete mix. Potable water, which is free from impurities and contaminants, is essential in ensuring consistent hydration and preventing the introduction of substances that could weaken the concrete. The quality and quantity of water used in FRC impact the mix's setting time, strength development, and durability. Using clean, potable water ensures that the concrete mix remains chemically stable, minimizing the risk of efflorescence or chemical reactions that could degrade the concrete over time. Properly measured water content also helps achieve a balance between workability and strength, allowing the concrete to flow and fill molds effectively while still meeting the structural requirements.

## 3. Materials and Methods

***Preparation and Testing of Fiber Reinforced Concrete***

The preparation of Fiber Reinforced Concrete (FRC) involves several critical steps, from sourcing raw materials and proportioning them according to standards to mixing, curing, and testing the concrete. The quality of the final product is heavily influenced by each of these steps, as well as by adherence to the guidelines set forth in the Indian Standards (IS) codes, such as IS 456:2000 and IS 10262, which provide specifications for concrete mix design and construction. FRC, designed to achieve an M20 grade, incorporates fibers such as glass, steel, and aramid to improve the tensile strength and toughness of the concrete, making it highly suitable for structures requiring enhanced durability and crack resistance.

***Material Collection and Testing***

The initial stage of preparing FRC involves sourcing the primary ingredients—cement, fine and coarse aggregates, fibers, water, and superplasticizers—from approved suppliers. Each material is collected from certified locations and then subjected to rigorous testing to ensure it meets the necessary physical and mechanical properties.

According to IS specifications, tests are conducted on each material to confirm quality and suitability. For instance:

- Cement is tested for its compressive strength, fineness, consistency, and setting time. These properties ensure that the cement will achieve the desired bonding and strength characteristics.

- Aggregates (both fine and coarse) undergo tests for grading, particle size distribution, specific gravity, and water absorption. Properly graded aggregates ensure the concrete achieves the required density, durability, and workability.

- Fibers are examined for tensile strength, elasticity, and aspect ratio to confirm their compatibility with the concrete mix. For FRC, glass, steel, and aramid fibers are chosen for their durability, high tensile properties, and compatibility with the cement matrix.

Testing these materials beforehand is essential to avoid variability in concrete quality and performance, ensuring that the finished concrete meets the project’s structural requirements.

***Proportioning of Ingredients as per Mix Design***

Based on IS 10262 and IS 456:2000, the FRC mix design is carefully calculated to meet the specified M20 grade requirements. This grade denotes that the concrete should achieve a compressive strength of 20 MPa at 28 days. Proportioning the ingredients accurately by weight and volume is a key step, as improper measurements could lead to compromised structural performance.

- Cement, fine and coarse aggregates, and fibers (glass, steel, and aramid) are proportioned by weight. The mix design specifies the fiber content percentages as 0.3%, 0.5%, and 0.7% by weight of cement for each fiber type, allowing each fiber to contribute to enhancing the concrete’s properties proportionally.

- Water and superplasticizers are measured by volume. Superplasticizers help achieve the desired workability, particularly since fibers can reduce the concrete’s natural flow. The water-cement ratio is controlled to optimize hydration and strength development without making the mix too fluid or too dry.

***Mixing Process in Concrete Mixer***

Mixing the FRC is carried out in a concrete mixer to ensure a uniform and consistent blend. The order of adding materials is crucial to achieving an even distribution of fibers within the matrix and maximizing the bonding between the fibers and the cement paste.

- Layering of Materials: The materials are laid in uniform layers in a specified order, starting with fine aggregate, followed by coarse aggregate, and then fibers (in the specified percentages of 0.3%, 0.5%, and 0.7%). This layering technique allows the fibers to be well-distributed in the dry mix, minimizing clumping or uneven fiber distribution.

- Dry Mixing: The materials undergo a thorough dry mixing process to ensure that the aggregates and fibers are evenly combined. Dry mixing is a critical step, as it disperses the fibers evenly and prevents them from clustering, which could compromise the mix's structural integrity.

- Addition of Cement and Water: After dry mixing, cement is added and mixed with the other ingredients to create a consistent blend. Finally, water is added gradually to control the mix's workability and ensure it has the proper consistency for placement.

***Slump Test for Workability***

Once the fresh concrete mix is prepared, it undergoes a slump test to evaluate its workability. The slump test measures the consistency of the concrete and its ability to flow, which can be affected by the inclusion of fibers at different percentages.

- Impact of Fibers on Slump: Since fibers can reduce the mix's natural flow, it is essential to perform the slump test after adding fibers in different proportions. The results help assess the impact of each fiber type on the workability and make adjustments to superplasticizer content if necessary. A well-controlled slump ensures that the concrete can be easily placed and compacted in molds without excessive segregation or bleeding.

***Casting and Curing Process***

Once the slump test confirms the concrete's workability, the FRC is filled into molds to create test specimens, such as cubes, which are essential for determining compressive strength.

- Filling Molds and Initial Setting: The concrete is carefully placed into empty molds, compacted to remove any air pockets, and left to set for 24 hours. Proper placement and compaction prevent voids and ensure a dense, strong concrete structure.

- De-molding and Curing: After the initial setting period, the cubes are carefully de-molded and transferred to a curing tank. The curing process is essential to allow the concrete to hydrate fully, achieving optimal strength and durability. Curing is typically done in water for 3, 7, and 28 days, allowing the concrete to develop its compressive strength gradually over time.

***Compressive Strength Testing***

After curing, the FRC specimens undergo compressive strength testing at intervals of 3, 7, and 28 days. Compressive strength testing provides insights into the concrete's load-bearing capacity and overall performance.

- Testing Intervals: Testing at 3 and 7 days allows for early assessment of strength development, while the 28-day test provides the final measure of the concrete's designed compressive strength.

- Effects of Fiber Content: Testing also reveals the effects of different fiber percentages on the concrete's compressive strength. Generally, the inclusion of fibers enhances the concrete's ability to withstand compressive forces and distributes stresses more evenly throughout the matrix, thereby increasing overall durability and toughness.

## 4. Results and Discussion

***Results of Compression Testing for M20 Grade Fiber Reinforced Concrete***

This section provides a detailed overview of the results from compression tests performed on M20-grade concrete using various fiber types—ordinary concrete (control), glass fiber, steel fiber, and aramid fiber—at different fiber percentages (0.3%, 0.5%, and 0.7%) over 3, 7, and 28-day curing periods. The results are summarized in tables, indicating the load (in kilonewtons and kilograms) and stress (in N/sq.mm) for each test.

### 1.1 ORDINARY CONCRETE

| M20 PCC | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 175 | 17600 | 7.92 N/SQ.MM |
| 7 days | 293 | 29200 | 12.88 N/SQ.MM |
| 28 days | 494 | 49200 | 21.67 N/SQ.MM |

**Table no.1**

***Ordinary Concrete (M20 PCC) Compression Test Results***

The compression test results for M20-grade ordinary Portland cement concrete (PCC) without fiber reinforcement are shown in Table 1. For the ordinary concrete samples, tests were conducted at intervals of 3, 7, and 28 days. At 3 days, the concrete attained a load-bearing capacity of 176 kN (17,600 kg), translating to a compressive stress of 7.82 N/sq.mm. At 7 days, this value increased to 292 kN (29,200 kg), achieving a compressive stress of 12.98 N/sq.mm. By 28 days, the load capacity reached 492 kN (49,200 kg), resulting in a final compressive stress of 21.87 N/sq.mm. These results serve as the baseline strength parameters for comparison with fiber-reinforced concrete variations.

### 1.2 GLASS FIBER

| M 20 [ 0.3 % ] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 189 | 18800 | 8.34 N/SQ.MM |
| 7 days | 279 | 27900 | 12.5 N/SQ.MM |
| 28 days | 493 | 49600 | 22.07 N/SQ.MM |

**Table no. 2**

| M 20 [ 0.5 % ] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 227 | 22700 | 10.08 N/SQ.MM |
| 7 days | 260 | 26900 | 11.95 N/SQ.MM |
| 28 days | 630 | 63000 | 28.00 N/SQ.MM |

**Table no. 3**

| M 20 [ 0.7 % ] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 199 | 19800 | 8.8 N/SQ.MM |
| 7 days | 332 | 33702 | 14.98 N/SQ.MM |
| 28 days | 652 | 65200 | 28.98 N/SQ.MM |

**Table no.4**

The results for M20-grade concrete mixed with glass fibers at varying concentrations (0.3%, 0.5%, and 0.7%) are detailed in Tables 2, 3, and 4, respectively. For the 0.3% glass fiber mix (Table 2), compressive stress after 3 days was recorded at 8.35 N/sq.mm, increasing to 12.4 N/sq.mm by 7 days, and achieving 22.04 N/sq.mm after 28 days. When the fiber content was increased to 0.5% (Table 3), the concrete displayed enhanced early strength, with a stress of 10.08 N/sq.mm at 3 days, 11.95 N/sq.mm at 7 days, and 28.00 N/sq.mm by 28 days. At 0.7% fiber content (Table 4), the stress values further improved, reaching 8.8 N/sq.mm at 3 days, 14.98 N/sq.mm at 7 days, and 28.98 N/sq.mm at 28 days. The increase in compressive strength with higher percentages of glass fiber indicates that glass fibers improve both the early and long-term strength of the concrete.

### 1.3 STEEL FIBER

| M 20 [ 0.3 % ] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 283 | 28300 | 12.57 N/SQ.MM |
| 7 days | 344 | 34300 | 15.24 N/SQ.MM |
| 28 days | 632 | 63000 | 23.24 N/SQ.MM |

**Table no.5**

| M 20 [ 0.5 % ] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 300 | 30000 | 13.35 N/SQ.MM |
| 7 days | 376 | 37300 | 16.58 N/SQ.MM |
| 28 days | 522 | 52100 | 24.31 N/SQ.MM |

**Table no.6**

| M 20 [ 0.7 %] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 313 | 31200 | 13.87 N/SQ.MM |
| 7 days | 364 | 36400 | 16.17 N/SQ.MM |
| 28 days | 625 | 62400 | 27.73 N/SQ.MM |

**Table no.7**

***Steel Fiber Reinforced Concrete (SFRC) Compression Test Results***

Steel fiber was incorporated into M20-grade concrete in 0.3%, 0.5%, and 0.7% concentrations, and the results are summarized in Tables 5, 6, and 7. For the 0.3% steel fiber mix (Table 5), the concrete achieved a compressive stress of 12.57 N/sq.mm at 3 days, 15.24 N/sq.mm at 7 days, and 23.24 N/sq.mm at 28 days. When the steel fiber content was increased to 0.5% (Table 6), the stress values rose to 13.33 N/sq.mm after 3 days, 16.57 N/sq.mm after 7 days, and 24.31 N/sq.mm after 28 days. At a 0.7% fiber content (Table 7), the compressive strength continued to improve, with values of 13.87 N/sq.mm, 16.17 N/sq.mm, and 27.73 N/sq.mm at 3, 7, and 28 days, respectively. These findings illustrate that the inclusion of steel fibers consistently enhances the compressive strength across all curing periods, particularly at higher percentages.

**1.4 ARMID FIBER**

| M 20 [ 0.3 %] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 543 | 54300 | 24.13 N/SQ.MM |
| 7 days | 574 | 57300 | 25.67 N/SQ.MM |
| 28 days | 660 | 66000 | 29.33 N/SQ.MM |

**Table no. 8**

| M 20 [ 0.5 %] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 564 | 56400 | 25.06 N/SQ.MM |
| 7 days | 701 | 70000 | 31.11 N/SQ.MM |
| 28 days | 847 | 84700 | 37.64 N/SQ.MM |

**Table no.9**

| M 20 [ 0.7 %] | | | |
|---|---|---|---|
| BLOCK | LOAD(KN) | LOAD(KG) | STRESS=LOAD/AREA |
| 3 days | 565 | 56200 | 24.98 N/SQ.MM |
| 7 days | 686 | 68600 | 30.40 N/SQ.MM |
| 28 days | 693 | 69200 | 30.75 N/SQ.MM |

**Table no.10**

***Aramid Fiber Reinforced Concrete (AFRC) Compression Test Results***

Aramid fiber was also introduced into M20-grade concrete at 0.3%, 0.5%, and 0.7% concentrations, with results recorded in Tables 8, 9, and 10. For the 0.3% aramid fiber content (Table 8), the concrete exhibited high early compressive stress of 24.13 N/sq.mm at 3 days, increasing to 25.67 N/sq.mm at 7 days, and reaching 29.33 N/sq.mm by 28 days. With a 0.5% fiber content (Table 9), compressive stress values further increased, achieving 25.07 N/sq.mm at 3 days, 31.11 N/sq.mm at 7 days, and a notable 37.64 N/sq.mm at 28 days. At 0.7% aramid fiber content (Table 10), the stress values were 24.98 N/sq.mm at 3 days, 30.49 N/sq.mm at 7 days, and 30.75 N/sq.mm at 28 days. The results demonstrate that aramid fibers provide a substantial increase in compressive strength, particularly in early-stage curing and at a fiber content of 0.5%.

**Comparison between Aramid fibre to Glass fibre and steel fibre on basis of Percentage increased in**

**strength of28 days**

| Grade of concrete | % of fibre | Aramid fibre | Glass fibre | % of increased |
|---|---|---|---|---|
| | | Stress (N/SQ.MM) | Stress (N/SQ.MM) | |
| M20 | 0.3 | 29.33 | 23.05 | 26.45 % |
| M20 | 0.5 | 37.65 | 28.00 | 48.2 % |
| M20 | 0.7 | 30.75 | 28.98 | 8.85 % |

| Grade of concrete | % of fibre | Aramid fibre | Steel fibre | % of increased |
|---|---|---|---|---|
| | | Stress (N/SQ.MM) | Stress (N/SQ.MM) | |
| M20 | 0.5 | 29.33 | 23.24 | 30.46 % |
| M20 | 0.3 | 37.45 | 24.31 | 66.65 % |
| M20 | 0.7 | 30.75 | 27.72 | 15.1 % |

## 5. Conclusion

The incorporation of fibers such as glass, steel, and aramid into concrete significantly enhances its compressive strength, toughness, and resistance to cracking. When comparing fiber types, it is evident that the impact of increased fiber dosage up to 0.5% significantly boosts the compressive strength of concrete for both glass and steel fibers. However, among the fibers tested, aramid fiber stands out for its substantial improvement in concrete's mechanical properties, especially when compared to glass and steel.

At a 0.5% dosage, aramid fiber provides a compressive strength increase of 48% over that of glass fiber, and a remarkable 66% more than steel fiber, demonstrating its superior reinforcing capability. This performance gain from aramid fiber reinforcement is particularly significant when considering its effectiveness in elevating the compressive strength of M20-grade concrete to levels comparable with M35-grade concrete.

The increase in compressive strength with aramid fiber results from its high tensile properties, excellent bonding with the cement matrix, and ability to control and distribute stress more effectively. Aramid fibers introduce high energy absorption capacity within the matrix, making it more resistant to both cracking and deformation under load. Additionally, aramid's flexibility and durability contribute to improved distribution of stress and reduced crack propagation, making it an ideal choice for structural applications requiring high strength and reliability.

In summary, aramid fiber reinforces concrete to achieve higher compressive strengths compared to glass and steel fibers, even at the same dosage levels. This makes aramid fiber a highly efficient material for enhancing concrete's durability, with the added benefit of achieving compressive strength akin to M35-grade concrete while utilizing an M20-grade mix.

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