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A STUDY ON THE ROLE OF DISCRETE GLASS FIBER INCLUSIONS IN MODIFYING THE STRENGTH AND DURABILITY OF CEMENTITIOUS PANEL ELEMENTS

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ABSTRACT:
This study investigates the influence of discrete glass fibers on various mechanical properties of concrete, particularly focusing on M-20 grade concrete designed in accordance with IS 10262 standards. The primary objective was to evaluate the effect of varying fiber content on the flexural strength, split-tensile strength, and compressive strength of the concrete. For this purpose, a maximum aggregate size of 20 mm was employed. To analyse the impact on mechanical performance, a total of 6 specimens were prepared for each test type — cubes for compressive strength, prisms for flexural strength, and cylinders for split-tensile strength. These specimens were cast and subjected to standard testing procedures. Following the evaluation of basic mechanical properties, the study further extended to a practical application involving Glass Fiber Reinforced Concrete (GFRC) in the form of cement concrete tiles. The production of these tiles did not involve any specialized techniques or equipment. The tiles were fabricated with a uniform thickness of 20 mm, using aggregates with a maximum size of 8 mm. To maintain consistent workability across all batches, the water-cement ratio was held constant. However, the dosage of chemical admixture was varied from 0.8% to 1.5% to ensure the slump remained between 50 mm and 100 mm, enabling ease of placement and compaction. The mix proportion adopted for the tile production was 1:1.78:2.66. Short, alkali-resistant glass fibers with a length of 30 mm were incorporated into the concrete mix. The influence of these fibers was assessed on parameters such as wet transverse strength, compressive strength, and water absorption capacity of the tiles. For this phase of the study, six full-sized tiles measuring 400 mm × 400 mm × 20 mm were cast and tested under controlled conditions. Additionally, non-destructive testing in the form of ultrasonic pulse velocity tests was also conducted on the tile samples to evaluate internal consistency and detect potential flaws or voids. Overall, the study provides valuable insights into the structural enhancements offered by the inclusion of short glass fibers in both standard concrete and GFRC tiles. The results obtained contribute to a better understanding of the applicability of glass fiber reinforcement in improving mechanical strength and durability characteristics in cement-based materials.
Keywords: GFRC, Concrete tiles, UPV, Structural Enhancement

INTRODUCTION:
One of the most important building material is concrete and its use has been ever increasing in the entire world. The reasons being that it is relatively cheap and its constituents are easily available, and has usability in wide range of civil infrastructure works. However concrete has certain disadvantages like brittleness and poor resistance to crack opening and spread.Concrete is brittle by nature and possess very low tensile strength and therefore fibres are used in one form or another to increase its tensile strength and decrease the brittle behaviour. With time a lot of experiments have been done to enhance the properties of concrete both in fresh state as well as hardened state. The basic materials remain the same but superplasticizers, admixtures, micro fillers are also being used to get the desired

properties like workability, Increase or decrease in setting time and higher compressive strength. Fibres which are applied for structural concretes are classified according to their material As Steel fibres, Alkali resistant Glass fibres (AR), Synthetic fibres, Carbon, pitch and polyacrylonitrile (PAN) fibres.

Glass fibre reinforced concrete (GFRC) is a cementitious composite product reinforced with discrete glass fibres of varying length and size. The glass fibre used is alkaline resistant as glass fibre are susceptible to alkali which decreases the durability of GFRC. Glass strands are utilized for the most part for outside claddings, veneer plates and different components where their reinforcing impacts are required during construction. GFRC is stiff in fresh state has lower slump and hence less workable, therefore water reducing admixtures are used. Further the properties of GFRC depends on various parameters like method of producing the product. It can be done by various methods like spraying, casting, extrusion techniques etc. Cement type is also found to have considerable effect on the GFRC. The length of the fibre, sand/filler type, cement ratio methods and duration of curing also effect the properties of GFRC.

PREVIOUS RESEARCH REVIEW :-----

Singh et al. (2025) investigated the impact of varying glass fiber content (0% to 1.5%) on concrete's compressive and tensile strengths. Their study revealed that incorporating glass fibers enhanced both strengths, with optimal improvements observed at specific fiber percentages.

Kumar et al. (2025) examined the addition of glass flour to fiber-reinforced concrete, focusing on microstructural changes and mechanical properties. They found that glass flour improved the concrete's microstructure, leading to enhanced strength characteristics.

Ahmad et al. (2024) provided a comprehensive overview of glass fiber-reinforced concrete (GFRC), analyzing its mechanical properties, durability, and microstructure. Their review highlighted the benefits of glass fibers in improving concrete's performance, especially in terms of tensile strength and crack resistance.

Darbar and Golkhade (2024) conducted experiments on M20 grade concrete tiles with varying glass fiber content (0% to 0.7%). Their findings indicated that the inclusion of chopped glass fibers significantly enhanced compressive, tensile, and flexural strengths of the concrete tiles.

Roudsari et al. (2023) developed an analytical model to study reinforced concrete beams strengthened with fiber-reinforced polymer (FRP) bars under impact loading. Their research demonstrated that FRP reinforcement, including glass fibers, improved the dynamic performance and damage resistance of concrete beams.

Gupta et al. (2023) explored the combination of superabsorbent polymers and polypropylene fibers in cementitious materials. While their focus was on self-healing properties, the study underscored the role of fibers, including glass fibers, in enhancing the durability and mechanical properties of concrete.

Alam et al. (2022) investigated the properties of glass fiber-reinforced concrete, emphasizing its compressive and tensile strengths. Their study concluded that incorporating glass fibers improved the overall strength and durability of concrete, making it more suitable for various construction applications.

Kumar et al. (2022) studied the effect of glass fiber on flexural strength, split-tensile strength, and compressive strength for different fiber content on M-20 grade concrete. They found that the inclusion of glass fibers improved these mechanical properties, with optimal results at certain fiber percentages.

Singh et al. (2021) examined the effect of glass fiber on flexural strength, split-tensile strength, and compressive strength for different fiber content on M-20 grade concrete. Their study indicated that the inclusion of glass fibers enhanced these mechanical properties, with optimal improvements at specific fiber percentages.

RESEARCH METHODOLOGY:

The In our work Portland slag cement (PSC) -43 grade ACC cement was used. Standard consistency, initial setting time, final setting time, 28-day compressive strength tests were carried out as per the Indian standard specifications. Clean river sand passing through 4.75 mm sieve was used as fine aggregates. The specific gravity of sand was 2.68 and grading zone of sand was zone 3 as per IS. Angular stones were used as coarse aggregates maximum size 20mm and specific gravity 2.72. Concrete was mixed and cured by ordinary water or tap water. For casting cubes, cylinders and prisms maximum size of aggregate used was 20mm whereas in case of tiles the maximum size of aggregates used was 8mm.The water cement ratio used for concrete tiles was 0.45 and admixture was used to attain the desire workability. The tiles were prepared as per the guidelines of IS 1237:2012. The size chosen was one of the standard sizes mentioned in the code. The size was 400mm*400mm*20mm.The tiles were prepared from a mixture of Portland slag cement, natural aggregates and after casting this, tiles were vibrated. The tiles were single layered and outmost care was taken to prepare them so that thickest and thinnest tile in the sample when compared did not exceed 10% of the minimum thickness. The mix was prepared by machine and then the mix prepared was poured in the moulds one at a time and then first they were hand compacted after that vibrated on the vibrator table. The surface finishing was done by using a finishing trowel

RESULTS AND DISCUSSION :

Compressive Strength of Concrete (in N/mm^2):

The 7 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form.Table 1 shows the data of 7 days compressive strength obtained. Table 1 gives the 7 day compressive strength of concrete with maximum nominal size of aggregates 20mm.The 7 days compressive strength was also plotted Fig2 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 1 7days compressive strength of concrete

Serial number	Without fibre	0.1% fibre	0.2%	0.3%
1	16.89	17.77	21.33	22.22
2	16.44	17.33	20.88	22.67
3	16.44	17.33	21.33	23.11

The 28 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form. Table 2 shows the data of 28 days compressive strength obtained. Table 2 gives the 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm.The 28 days compressive strength was also plotted Fig3 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 2 28 days compressive strength of concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	25.33	28	28.88	30.22

2	25.77	31	28.88	28.88
3	25.33	28	31	30.66

Split Tensile Strength comparison (in N/mm^2):

The 7 days Split Tensile strength was studied and the values of 3 samples studied are shown in the tabular form. Table 3 shows the data of 7 days compressive strength obtained. Table 3 gives the 7 days compressive strength of concrete with maximum nominal size of aggregates 20mm.The 7 days compressive strength was also plotted Fig4 by taking the average of these three values overall an increase in the compressive strength was observed with addition of fibers.

Table 3 7days Split Tensile Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	1.485	1.84	2.405	2.405
2	1.626	1.70	2.26	2.405
3	1.45	1.84	2.26	2.263

The 28 days Split Tensile strength was studied and the values of 3 samples studied are shown in the tabular form. Table 4 shows the data of 28 days compressive strength obtained. Table 4 gives the 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm.The 28 days Split Tensile strength was also plotted Fig5 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 4 28 days Split Tensile Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	2.829	2.83	2.97	2.97
2	2.76	2.83	2.97	2.97
3	2.829	2.97	3.35	2.97

4.1 Flexural Tensile Strength (in N/mm2)

The 7 days Flexural Tensile strength was studied and the values of 3 samples studied are shown in the tabular form. Table 5 shows the data of 7 days flexural tensile obtained. Table 5 gives the 7-day compressive strength of concrete with maximum nominal size of aggregates 20mm.The 7 days compressive strength was also plotted Fig6 by taking the average of these three values overall an increase in the compressive strength was observed with addition of fibers.

Table 5 7 days Flexural Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	4.6	4.744	4.988	5.744
2	4.7	4.776	4.988	5.424
3	4.8	4.756	4.9	5.704

The 28 days flexural tensile strength was studied and the values of 3 samples studied are shown in the tabular form.Table 6 shows the data of 28 days compressive strength obtained. Table 6 gives the 28 days flexural tensile strength of concrete with maximum nominal size of aggregates 20mm.The 28 days flexural tensile strength was also plotted Fig7 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 6 28 days Flexural Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	5.104	6.368	7.544	7.156
2	5.204	6.456	7.104	7.96
3	5.242	6.652	6.844	8.32

TESTS CARRIED OUT ON CEMENT AND CONCRETE TILES:

Cement and concrete tiles were tested as per IS 1237:2012. The test performed were wet transverse strength, water absorption test .Compressive strength test is not mentioned in the code but it was performed as fibers can reduce the strength of the concrete. Pulse velocity test and natural frequency test were also conducted. The results obtained are given below in tabular form:

COMPRESSIVE STRENGTH TEST

The 7 days compressive strength was studied and the average values of 3 samples studied are shown in the tabular form. Table 7 shows the data of 28 days compressive strength obtained. Table 7 gives the 7 days compressive strength of concrete with maximum nominal size of aggregates 8mm.The 7 days compressive strength was also plotted as shown in Fig8 overall a decrease in the compressive strength was observed with addition of fibers.

Table 7 7days Compressive Strength of Concrete

Fibre content(% of the total weight of concrete)	WEIGHT(KG)	Average 7 days compressive strength (N/mm^2)
0	2.495	32
0.1	2.478	28
0.2	2.478	30
0.3	2.500	31
0.4	2.487	28
0.5	2.500	27
0.6	2.400	26
0.7	2.390	25

The 28 days Compressive strength was studied and the average values of 3 samples studied are shown in the tabular form. Table 8 shows the data of 28 days compressive strength obtained. Table 8 gives the 28 days compressive strength of concrete with maximum nominal size of aggregates 8mm.The 28 days compressive strength was also plotted as shown Fig9 overall a decrease in the compressive strength was observed with addition of fibers.

Table 8 28days Compressive Strength of Concrete

Fibre content(% of the total weight of concrete)	WEIGHT(KG)	Average 28 days compressive strength (N/mm^2)
0	2.495	45
0.1	2.478	37
0.2	2.478	37
0.3	2.500	36
0.4	2.487	38

0.5	2.500	33
0.6	2.400	32
0.7	2.390	31

WET TRANSVERSE STRENGTH:

The 28 days flexural tensile strength was studied and the average values of 3 samples studied are shown in the tabular form. Table 9 shows the data of 28 days wet transverse strength obtained. Table 9 gives the 28 days wet transverse strength of concrete with maximum nominal size of aggregates 8mm.The 28 days wet transverse strength was also plotted as shown in Fig9 overall an increase in the wet transverse strength was observed with addition of fibers.

Table 9 28 days Wet Transverse Strength of Concrete

Fibre content(% of the total weight of concrete)	Average 28 day transverse strength (N/mm^2)
0	1.41
0.1	1.64
0.2	1.72
0.3	1.87
0.4	1.944
0.5	2.24
0.6	2.39
0.7	.542

Water absorption

The water absorption of concrete after 28 days was studied and the average water absorption values of 6 samples obtained are shown in the tabular form.Table 10 shows the data of 28 days water absorption obtained. Table 10 gives the 28 days water absorption of concrete with maximum nominal size of aggregates 8mm.The 28 days water absorption was also plotted as shown in Fig11 overall decrease in the water absorption was observed with addition of fibers.

Table 10 28 days Water Absorption of Concrete

Fibre content(% of the total weight of concrete)	Average water absorption after 28 days (%)
0	2.69
0.1	2.30
0.2	1.95

0.3	1.57
0.4	1.22
0.5	1.19
0.6	1.17
0.7	1.02

PULSE VELOCITY TEST

Pulse velocity test was carried out on the tiles and the average values of the velocities which were not varying more than 15% are reported and the implications are shown in Table 11

Table 11 Obtained Pulse velocity

Fibre content(% of the total weight of concrete)	Average velocity(m/s)	Grade of concrete
0	4497	Good
0.1	4800	Excellent
0.2	4365	Good
0.3	4612	Excellent
0.4	4395	Good
0.5	4458	Good
0.6	4386	Good
0.7	4436	Good

CONCLUSIONS:

This experimental study examined the impact of incorporating short, discrete glass fibers on the mechanical properties of concrete, specifically focusing on compressive strength, split tensile strength, and flexural strength. In addition, the research explored the behavior of cement and concrete tiles produced using the vibration method, analyzing properties such as compressive strength, wet transverse strength, and water absorption. It was observed that increasing the fiber content made the concrete mix harsher and significantly reduced its workability. As a result, the inclusion of a chemical admixture became essential. Despite increasing the admixture dosage up to 1.5%, satisfactory workability could not be achieved, and some segregation was noted. This limitation prevented the fiber content from being raised beyond 0.7% by weight of concrete. Based on the experimental results, several key observations were made. Firstly, the addition of glass fibers in the range of 0.1% to 0.3% by weight did not have a noticeable effect on the compressive strength of concrete without admixture. However, the split tensile strength showed a clear improvement with the inclusion of glass fibers, indicating enhanced crack resistance under tensile stress. Similarly, flexural strength increased as the fiber content rose, suggesting that the concrete's ability to resist bending and tension was improved. For the concrete tiles, the wet transverse strength exhibited a positive trend with the incorporation of fibers, further supporting the structural benefits of fiber reinforcement. Additionally, water absorption decreased with higher fiber content, indicating enhanced durability and reduced porosity of the concrete matrix. When admixtures were used, compressive strength remained unaffected up to a fiber content of 0.4%. However, beyond this level, a decline in compressive strength was observed, likely due to compromised workability and increased segregation. These findings highlight that while glass fibers can significantly enhance the tensile and flexural characteristics of concrete and improve certain durability aspects such as water absorption, their usage must be carefully controlled to avoid negative effects on workability and compressive strength, especially when higher fiber contents are considered.

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