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Research on Glass Fiber Reinforced Concrete with Partial Replacement of Cement with Marble Dust Powder

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Abstract
The purpose of this research work is to investigate the strength properties of glass fiber reinforced concrete with partial cement replacement by marble dust powder. Several of the most complex environmental concerns are now being addressed. Many of the items we create for our affluent lifestyles contribute to environmental pollution as a result of inadequate waste management. To mitigate these drawbacks, it is possible to highlight the reuse of waste materials such as marble dust powder. Internal micro fractures are a natural feature of concrete, and their growth is the cause of its low tensile strength. Glass fibers can be added to counteract these drawbacks. When fibers are introduced to concrete at a certain percentage, strain qualities like crack resistance, ductility, flexure strength, and toughness improve. This study report examines the impact of MDP and glass fiber in concrete on strength. The concrete grade is M30.Compressive strength, split tensile strength, and flexural strength of concrete can be improved by replacing 0%, 5%, 10%, and 15% of the cement weight with marble powder, and adding 0 percent, 0.5 percent, 1 percent, and 1.5 percent of the concrete weight with glass fiber. The water/cement ratio 0.45 was maintained in all concrete mixtures. At 7 and 28 days, the compressive strength, split tensile strength, and flexural strength of the concrete mixtures were measured. The laboratory results reveal that replacing cement with MDP enhanced concrete compressive strength, split tensile strength, and flexural strength by up to 10%, while glass fiber increased flexural strength by up to 1%.

Keywords: *Glass Fiber, Marble Dust Powder, Compressive Strength, Split Tensile Strength, Flexural Strength*

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I. INTRODUCTION

Concrete has become an important component of our lives because it can be seen all around us. Marble is a rock that results from the transformation of pure limestone. MDP is created as a by-product of the quarrying process from marble rock that contains more than 50% calcium oxide. MDP may be a viable alternative in a cementitious binder since the presence of lime boosts its reactivity efficiency. According to estimates, the world's quarries produce several million tonnes of MDP each year. A considerable amount of MDP is created during the cutting process. As a result, marble powder has become a crucial alternative material for increasing concrete hardening properties. To improve its qualities, concrete has been combined with a variety of different building materials, including fibre concrete. GFRC is a fiber-based concrete in which the fibres are equally distributed and partially aligned with other materials such as cement, aggregates, sand, water, and so on. Internally, these fibres support the concrete. The length of fibre may vary depending on the specific aim. GFRC is commonly utilised in construction countertops, exterior facade construction or repair, drainage, and architectural work such as cladding. Furthermore, the supply of natural aggregate and minerals required to make cement is limited, and it is vital to reduce energy consumption and greenhouse gas emissions associated with construction operations. A solution to the current situation is to employ glass fibre and MDP as a partial replacement for cement.

II. LITERATURE REVIEW

2.1 GENERAL

Several studies on glass fiber reinforced concrete and marble dust powder have been undertaken in recent years. The work of various researchers have been studied and discussed below.

2.2 REVIEW OF LITERATURE

Khan et al. (2016) conducted a experimental study on glass fiber concrete found that adding glass fiber to concrete improves its workability by 1%. In addition, the 1 percent increase in workability increased the compressive, flexural, and split tensile strength of M-20 grade concrete at 7 and 28 days. In comparison to ordinary concrete, glass fiber concrete showed a gradual rise in compressive strength. Furthermore, the addition of glass fiber reduces workability by 1%. For 7 days, the flexural strength, compressive strength, and split tensile strength remain high at 1 percent. They came to the following general conclusion.

- The addition of glass fibers at 0.5%, 1%, 2% and 3% of cement reduces the cracks under different loading conditions.
- It has been observed that the workability of concrete increases at 1% with the addition of glass fiber.
- The increase in compressive strength, flexural strength, split tensile strength for M-20 grade of concrete at 7 and 28 days are observed to be more at 1%.

Rao et al. (2010) conducted an experiment to determine the strength properties of glass fiber concrete .They conclude that adding glass fiber to the concrete mix reduces bleeding, which improves uniformity, surface integrity, and reduces the chances of cracks. In addition, as compared to 28 days of various grades of concrete mixes, compressive strength increased by 20% to 25%, flexural and split tensile strength increased by 15% to 20%. They came to the following general conclusion.

- Reduced bleeding enhances the surface integrity of concrete, increases its uniformity, and lowers the risk of cracks.
- The percentage increase in compressive strength of various grades of glass fiber concrete mixes compared to 28 days is 20 to 25%, and the percentage increase in flexural and split tensile strength of various grades of glass fiber concrete mixes compared to 28 days is 15 to 20%.

Deshmukhet al. (2012) conducted a study on the Effect of Glass Fibers on Ordinary Portland cement Concrete, finding that the mechanical characteristics and durability of the concrete are optimum at 0.1 percent fraction of fiber. With more glass fiber, compressive strength increases moderately but flexural and split tensile strength increases dramatically. They came to the following general conclusion.

- The inclusion of glass fibers to the concrete mixture improves the compressive strength marginally after 28 days.
- The compressive strength of concrete, flexural strength of concrete, and splitting tensile strength of concrete all improve with the addition of Percentage of glass fibers, according to the experimental results and analyses.
- The addition of 0.1 percent glass fibers to the concrete improves mechanical characteristics and durability.

Mohd. Afaque Khan et al. (Mar 2016) investigated "Compressive Strength Of Concrete Using Marble Dust As Partial Replacement Of Cement" and found that adding marble powder to concrete increases compressive strength up to a point, but thereafter steadily diminishes. When compared to 14 days to 28 days, an increase in curing days will increase the strength of marble dust concrete. To reduce construction costs by using marble powder, which is freely or inexpensively available. It is critical to determine the exact places in which this mixture can be used. As civil engineers, our primary goal is to reduce environmental contamination caused by cement manufacture. They came to the following general conclusion.

- Increase in curing days will increase the strength of marble dust concrete when compared from 14 days to 28 days.
- To minimize the costs of construction with usage of marble powder, which is freely or cheaply available It is essential to find out the specific areas where this mix can be used.

Abdullah Anwar et al. (2014) conducted research on "Study of compressive Strength of Concrete by Partial Replacement of Cement with Marble Dust Powder" and found that marble dust powder has the potential to be a viable alternative to cement in terms of environmental and economic balance. The compressive strength values of concrete containing marble dust powder at 0%, 5%, 10%, 15%, 20%, and 25% Portland cement. The 28-day compressive strength result reveals that the appropriate percentage for replacing cement with marble dust powder is approximately 10%. As a result, there will be less carbon dioxide produced, and environmental pollution caused by cement manufacture will be reduced, enhancing the urban environment. They came to the following general conclusion.

- The 28-day compressive strength result reveals that the ideal percentage of marble dust powder substitution for cement is around 10%.

III. METHODOLOGY

3.1 Methodology

The effects of glass fibers on compressive strength tests on M30 grade concrete for different percents of glass fiber, i.e., 0%, 0.5%, 1%, and 1.5% by weight of cement, are studied in this research. The characteristics of concrete are improved when marble dust powder is used as a replacement. In M30 grade concrete, by partially substituting the cement with marble dust powder in the range of 5%, 10%, and 15% by weight of cement. The design mix will be calculated to achieve a target strength of 30N/mm2. Consistency testing will be used to determine the water cement ratio needed for the design mix calculation. Initially, a trial will be run to determine the proper mix ratio. Then, in that mix ratio by volume, MDP will be used to replace cement. The design mix must be altered after the replacement. The new design mix's setup time must then be determined. To test with four different MDP dosages of 0%, 5%, 10%, and 15% to establish the best percentage of marble dust powder for M30 grade concrete based on compressive, tensile, and flexural strength. To compare the compressive behavior of glass fiber reinforced concrete to that of conventional concrete of the same concrete grades.

IV. MATERIALS AND METHODS

4.1 Cement

Cement is a binding material in concrete which binds the other material to forms a compact mass. Generally OPC is used for all engineering construction works. The specific gravity of all grade of OPC is 3.15. OPC is available in three grades. In this study, OPC 53 grade cement is used. For ordinary Portland cement, the initial setting time is 32 minutes and the final setting time is 600 minutes.

4.2 Aggregate

Fine aggregate is a material such as sand, crushed stones or crushed gravel passing through 4.75 mm size. M sand is used as fine aggregate in this study. The specific gravity of fine aggregate is 2.66. Fineness modulus is 3.15 and unit weight of fine aggregate is 1600kg/m^3. Water absorption is 1.1%. The grading of Fine aggregate as per IS: 383-1970 is confined by Zone III.

Material which retained on 4.75 mm size is classified as coarse aggregate. For most works, 20 mm aggregate is suitable. In this study 20 mm size of aggregate is used. The specific gravity of coarse aggregate is 2.65. Fineness modulus is 6.5 and unit weight of coarse aggregate is 1600kg/m^3. Water absorption is 1.5%.

4.3 Marble Dust Powder

The Marble dust powder was collected from the locally available manufacturing unit. It was sieved by IS-90 micron sieve before mixing in concrete. The specific gravity of marble dust powder is 2.68.

4.4 Glass Fiber

It is the material made from extremely fine fibers of glass. It is a light weight, extremely strong and robust material. The glass fibers are of Cem-FIL Anti-Crack HD with Modulus of Elasticity 72 GPA, Filament diameter 14 microns, Specific Gravity 2.68, length 12mm and having the aspect ratio of 857.1.

4.5 Mix Proportion

M30 grade of design mix according to IS 10262 was utilised in this research. The cement, fine aggregate, and coarse aggregate proportions in the concrete mix are 1: 2.05 : 3.49 by volume, with a water cement ratio of 0.45.

Table-1: Mix proportion

W/C Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.45	1	2.05	3.49

4.6 Casting and Curing

Casting and Curing Detail: Marble powder were added in concrete in step of 5% (0%, 5%, 10%, 15%).Glass fiber were added in concrete in step of 0.5% (0%, 0.5%, 1%, 1.5%). For each percent of marble powder replacing Cement and addition of glass fiber, 3 cubes, 3 cylinders and 3 prism were casted for 7 days and 28 days and additionally 1 beam were casted. Final strength of cube, cylinder and beam were tested after 7& 28 days curing.

V. TEST PROCEDURE

5.1 Compression Test

Cubes of 150 x 150 x 150 mm were cast and tested for compressive strength according to IS: 516-1959 on a compression testing equipment with a capacity of 2000 kN.

5.1.1 Procedure

The Compressive Strength Test is carried out according to the steps below.

1. Averaging perpendicular dimensions at least twice determines the size of the test specimen.
2. Center the specimen on the compression testing machine, and apply a constant and uniform load to the surface perpendicular to the tamping direction.
3. Increase the weight until the specimen fails, then record the highest load handled by each specimen during the test.

The following is how compressive stress was calculated:

Compressive strength = P/A x 1000

Where, P = Load in KN

A = Area of cube

5.2 Split Tensile Strength Test

For the splitting tensile strength test, cylinders with a diameter of 150 mm and a length of 300 mm were cast and tested on a compression testing machine in accordance with IS: 5816-1999.

5.2.1 Procedure

The tensile strength test is carried out according to the steps below.

1. Draw diametrical lines in the same axial plane on the two ends of the specimen.
2. Averaging the diameters of the specimen lying in the plane of pre-marked lines measured near the ends and the middle of the specimen will give you the diameter to the nearest 0.2 mm. By averaging the two lengths measured in the plane including pre-marked lines, the length of the specimen must also be taken to be within 0.2 mm.
3. Center one of the plywood strips in the lower platen's centre. Place the specimen on the plywood strip and orient it so that the lines on the specimen's end are vertical and centred.
4. The second plywood strip is centred on the lines marked on the cylinder's ends and placed lengthwise on the cylinder.
5. Apply the load without shock and gradually raise it until no further load can be sustained, resulting in a split tensile stress of roughly 1.4 to 2.1 N/mm2/min. Note the maximum load on the specimen. 6. The split tensile strength was calculated as follows:

Split tensile strength = 2P/πdL x 1000

Where, P = Load in KN = 3.142

d = Diameter of cylinder

L = Length of cylinder

5.3 Flexural Strength Test

For the flexural strength test, 100 x 100 x 500 mm beams were cast and tested on a 400 mm effective span with two point loading according to IS: 516- 1959.

5.3.1 Procedure

The flexural strength test is carried out according to the steps below.

1. Clean the beam with a brush. Place the beam in the breaking machine on its side, facing away from the moulded position.
2. Align the bearing plates squarely with the beam and adjust the distance using the machine's guide plates.
3. To help distribute the load, place a strip of leather or similar material under the upper bearing plate.
4. Turn the screw in the plunger's end to bring the jack's plunger into contact with the ball on the bearing bar.
5. Once contact has been made and only strong finger pressure has been applied, set the dial gauge needle to "0." We're going to apply two point loading to the beam specimen, and we're going to keep going until it breaks.
6. The flexural strength was calculated as follows:

Flexural strength = PL/bd2 x 1000

Where, P = Load in KN

L = Effective length of prism

b = Width of the prism

d = Depth of the prism

VI. RESULT AND DISCUSSION

6.1 Compressive Strength Test

Concrete's compressive strength is measured on a cube at various marble powder and glass fibre content levels. Concrete strength was evaluated on a cube after 7 days and 28 days of curing. A seven-day test was carried out to determine the increase in concrete's initial strength. The 28-day test determines the concrete's final strength after 28 days of curing. The compressive strength of concrete is tested using a compression testing machine. The strength of concrete steadily increases with the addition of marble powder and glass fiber up to a point, then gradually diminishes. The initial strength gain in concrete is substantial when marble powder is added up to 10% and glass fibre is added up to 1%.

Table 6.1 Compressive Strength Test Result

S.No	Glass Fiber (%)	MDP (%)	Compressive Strength (N/mm^2)	
			7 Days	28 Days
M1	0	0	22.97	33.18
M2	0.5	5	23.85	34.67
M3	1	10	24.44	35.85
M4	1.5	15	20.89	30.22

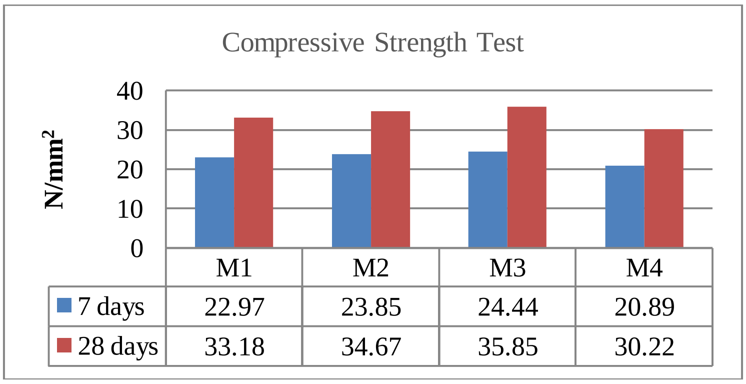

Chart 6.1 Compressive Strength Test Result

6.2 Split Tensile Strength Test

Concrete's split tensile strength is measured on a cylinder at various marble powder and glass fibre content levels. Concrete strength was evaluated on a cube after 7 days and 28 days of curing. To measure the growth in concrete's initial strength, a seven-day test was conducted. The 28-day test determines the concrete's final strength after 28 days of curing. The split tensile strength of concrete is tested using a compression testing machine. The strength of concrete steadily increases with the addition of marble powder and glass fiber up to a point, then gradually diminishes. The initial strength gain in concrete is substantial when marble powder is added up to 10% and glass fibre is added up to 1%.

Table 6.2 Split Tensile Strength Test Result

S.No	Glass Fiber (%)	MDP (%)	Split Tensile Strength (N/mm^2)	
			7 Days	28 Days
M1	0	0	3.11	4.00
M2	0.5	5	3.13	4.04
M3	1	10	3.16	4.27
M4	1.5	15	2.52	3.30

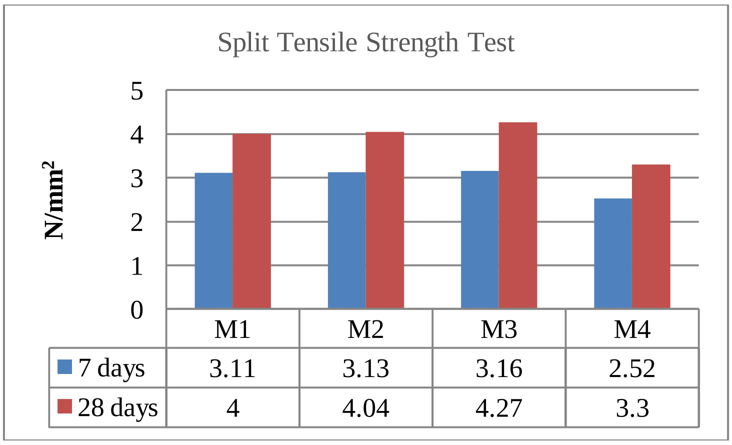

Chart 6.2 Split Tensile Strength Test Result

6.3 Flexural Strength Test

Concrete's flexural strength is measured on a cylinder at various marble powder and glass fibre content levels. Concrete strength was evaluated on a cube after 7 days and 28 days of curing. To measure the growth in concrete's initial strength, a seven-day test was conducted. The 28-day test determines the concrete's final strength after 28 days of curing. The flexural strength of concrete is tested using a flexural testing machine. The strength of concrete steadily increases with the addition of marble powder and glass fiber up to a point, then gradually diminishes. The initial strength gain in concrete is substantial when marble powder is added up to 10% and glass fibre is added up to 1%

Table 6.3 Flexural Strength Test Result

S.No	Glass Fiber (%)	MDP (%)	Flexural Strength (N/mm^2)	
			7 Days	28 Days
M1	0	0	3.07	5.33
M2	0.5	5	3.17	5.43
M3	1	10	3.20	5.63
M4	1.5	15	2.70	4.70

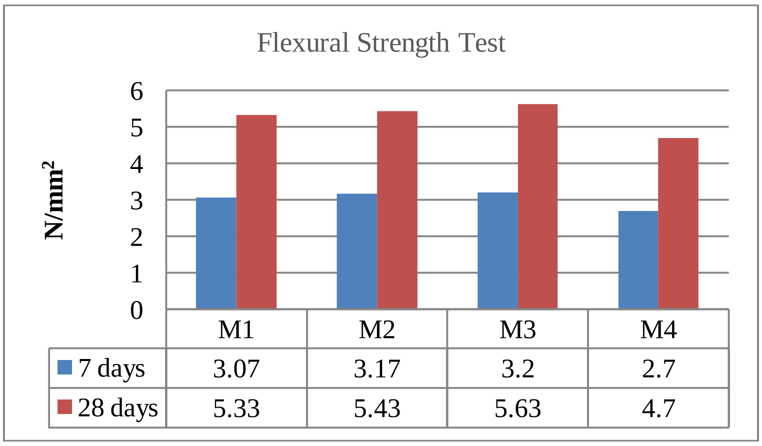

Chart 6.3 Flexural Strength Test Result

6.4 Test on Structural Specimen Beam

Beam is casted for the 10% replacement of marble powder with cement and addition of 1% of glass fiber for which the compressive strength and Split tensile strength was higher. The load deflection data of the concrete beam is shown in the Table 6.4

Ultimate Load = 60 Kn

Table 6.4 Result on Structural Specimen Testing for M3 at 28 Days

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0
2	3	0.78
3	6	1.42
4	9	2.61
5	12	3.37
6	15	4.56
7	18	5.92
8	21	7.08
9	24	8.14
10	27	9.66
11	30	10.28
12	33	11.54

13	36	12.95
14	39	3.83
15	42	14.47
16	45	15.86
17	48	16.94
18	51	17.68
19	54	18.41
20	57	19.72
21	60	20.23

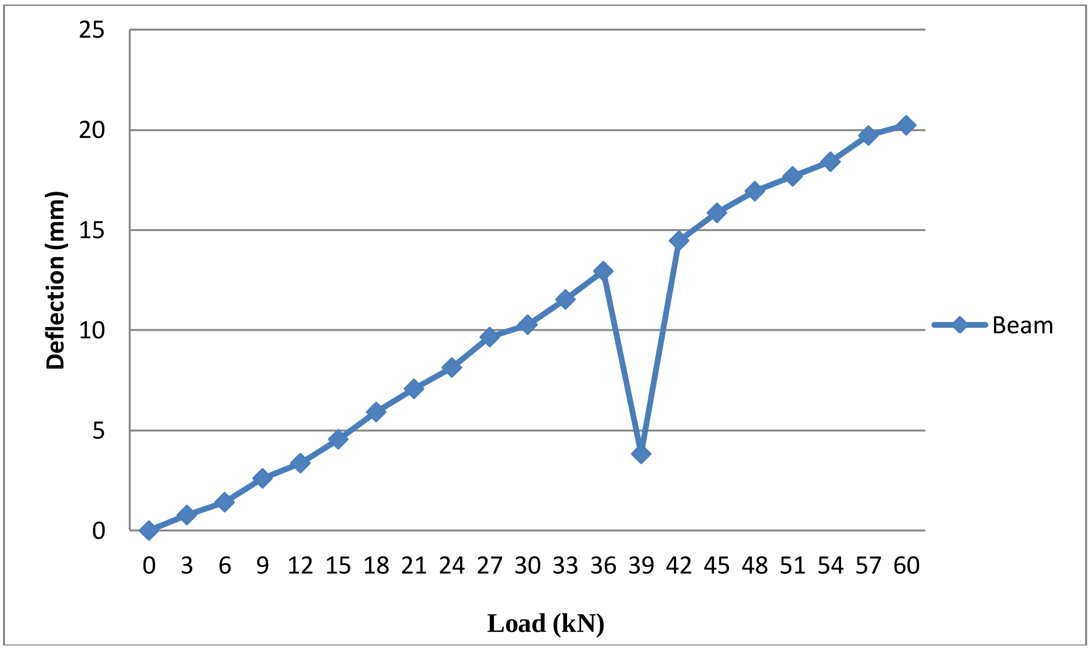

Chart 6.3 Structural Specimen M3 at 28 Days

VII.CONCLUSION

The addition of marble dust powder up to 10% by weight of cement and up to 1% of glass fibre by up to weight of concrete increases the compressive strength, split tensile strength, and flexural strength. Compressive strength, Split Tensile strength, and Flexural strength are all reduced when waste marble dust is added. With the inclusion of Glass Fibres, the workability of concrete has been reported to diminish. It has also been observed that when comparing Plain Concrete to Glass Fibre Reinforced Concrete, there is a gradual increase in early strength for Compression and Flexural strength.

As a result, we conclude that the most suitable percentage replacement of marble dust in concrete is 10% and Glass fibre is 1%. As a result, we discovered the best percentage for replacing marble dust with cement, which is nearly 10% cement for cubes, cylinders, and prisms. Glass fibre assists concrete in increasing compressive strength until the specified limit is reached. Because increasing the proportion of glass fibre in concrete has an effect on the bond between the components, as shown in the result, there is a limit to that percentage. In comparison to other outcomes, the best results are obtained for 1 percent of cementitious weight added.

As a result, GFRC is commonly used in the construction and repair of building outside facades, drainage, architectural cladding, and other applications. It was also determined that substituting marble dust powder for cement boosts the compressive strength of concrete by a few percentage points when compared to standard concrete. Because it helps to environmental and economic balance, marble dust powder has the potential to be a viable alternative to cement. As a result, less carbon dioxide will be created, and pollution from cement manufacturing will be minimised, benefiting the urban environment.

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