Experimental Investigation to assess the mechanical properties of Glass powder concrete (GPC)

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Abstract:

GPC has been utilized to create a wide variety of concrete items, including domes, statues, planters, and thin architectural cladding panels. In India, only about 45% of glass waste is recycled annually. Glass must be recycled since it does not degrade. Glass may be recycled countless times without losing its quality or purity and is practically entirely recyclable.

The experimental program consisted of preparing different mixes of concrete, where the glass powder was used as a partial replacement for fine aggregate. The percentage of replacement varied from 0%, 2.5%, 5%, 7.5%, & 10%.

The characteristics of the concrete were assessed in both their fresh and hardened states. Workability and other newly developed qualities were measured, and at different ages (7 and 28 days), compressive strength and flexural strength were examined.

Keywords: Glass Powder, Compressive Strength, flexural strength, Workability.

Introduction

This Project is about the effective use of Glass powder as a replacement of fine aggregate and to study the effect on the strength of concrete. So first, we will introduce Glass powder strength characteristics of glass powder concrete is significant for the construction industry as it can lead to the development of high-performance concrete with improved durability and longevity. The use of glass powder in concrete can also contribute to reducing the environmental impact of construction activities and promoting sustainability. In this study, fine aggregate is replaced with glass powder up to 10% by weight, and compressive and flexural strength are assessed. Various studies that can help the construction industry by offering a viable and affordable solution for enhancing the performance and durability of concrete structures are taken into consideration by various researchers.

I. Material used

1.1 Cement (OPC)

1.2 Coarse Aggregate

1.3 Fine Aggregate

1.4 Glass Powder

1.1 Cement (OPC) -

Fineness of cement

In the last step of manufacturing cement, hardened clinker is ground in fine particles. The size of fined particles is called fineness. The better will be fineness better will be workability.

Consistency of cement

The degree of the flow of cement in concrete and masonry is known as consistency. It is measured by Vicat Test.

Strength of cement

Cement has two types of strength- compressive, and tensile.

Figure 1: Cement

1.2 Coarse Aggregate - The larger material particles used in concrete and construction are referred to as coarse aggregate, sometimes known as crushed stone or gravel. It is often made up of diverse rock fragments that have been crushed and separated into various sizes, such as granite, limestone, or gravel. An key component of concrete, coarse aggregate is crucial to the end product's strength and durability.

Figure 2: Coarse Aggregate

1.3 Fine Aggregate - Fine aggregate, commonly referred to as sand, is a granular substance that typically has smaller particle sizes than coarse aggregate. It is a crucial ingredient in mortar, concrete, and many other construction-related products. The size of the particles in fine aggregate ranges from 0.075 mm (No. 200 sieve) to 4.75 mm (No. 4 sieve). The size of the particles is between that of silt or clay and that of coarse aggregate. Depending on regional norms and specifications, the precise size range may change.

Figure 3: Fine Aggregate

1.4 Glass Powder - Glass that has been finely ground into powdery-like particles is referred to as glass powder. It is normally made by first pulverising glass into tiny pieces, then crushing or grinding those pieces into powder. Depending on the intended use, the resulting powder can have particles that are very tiny or coarse.

In concrete and other building materials, glass powder can be used in place of some of the Fine Aggregates. It can strengthen, last longer, and make concrete easier to work with when combined with cement. Utilising leftover glass lowers the environmental effect of concrete production.

Use of Glass Powder

- Acidic soil improved by glass powder.
- Geotechnical purpose.
- Road construction, embankment, and flyovers.
- Raw material for cement.

Benefits of Glass Powder

- Low Manufacturing cost.
- Good strengths
- Require less water quantity
- Glass powder based bricks, blocks minimize the pollution.

Figure 4: Glass Powder

II. Methodology

2.1 Mix Design-

In accordance with IS Code 10262:2019, M30 grade of concrete is made ready for casting the test specimens. Glass Powder is used in the mixture in place of the fine aggregate. Glass powder has been substituted for fine aggregate in five samples—S, S1, S2, S3, and S4—in amounts of 0%, 2.5%, 5%, 7.5%, and 10% by weight, respectively.

Figure 5: Design Mix

2.2 Test Performed on Concrete Mix

In this project, we study two-parameter of concrete, test for fresh concrete, second slump test. The theory of these tests are listed below.

Test for Fresh Concrete

It is said that concrete is workable if it can be simply moved, laid, compacted, and finished without segregation or pumping capability. Although each of these concepts has a unique meaning, they are all connected to workability. For information on the quality of fresh concrete, it is crucial to consider its potential strength, long-term viability, and consistency. A slump test is another method for determining if glass powder concrete is workable.

Slump Test

The test's instrument is a frustum of a cone with internal bottom and top diameters of 20 cm and 10 cm, respectively, and a 30 cm height. The mould has been thoroughly cleaned and lubricated. While pouring concrete into the mould, it must be held firmly in place. Four layers of roughly 7.5 cm thick concrete should be poured into the mould, and each layer should be tamped with 25 strokes of a tamping rod with a rounded end. The top surface should be levelled out using a trowel after tamping. Now, lift the mould vertically while being cautious and slowly. The unsupported concrete will be able to sink or droop as a result. The term "slump" refers to the vertical settlement of slumped concrete. The slump is the difference between the top of the concrete when it has subsided and its starting height in the mould.

Figure 6: Slump Test Apparatus

2.3 Test For Hardened Concrete

In this research, we examine the concrete's two parameters: first compressive strength test and second flexural strength test. The following is a list of the test theories.

Compressive strength of concrete -

Concrete is appropriate for building arches, columns, dams, foundations, and tunnel linings because of its remarkable ability to withstand compressive loading. In residential and commercial projects, the compressive strength of concrete typically ranges from 17 MPa to 28 MPa and higher. Any material's compressive strength can be calculated using the compressive strength formula. Does the load that was imparted to the face's cross-section at the failure point still exist?

Compressive Strength. = Load/Cross-sectional Area

Figure 7: Compressive Testing Machine

Flexural Strength Test -

Flexural test-in this test the concrete beam after curing at 28 days is tested by a UTM machine to know the loading at which material fails and the failure position. This test gives tensile strength of concrete. The test results are given below.

Figure 8: Flexural Testing Machine

III. RESULT

3.1 Mix Design Proportion -

Sample	Glass Waste (%)	Fine Aggregate (F.A) (gm)	Coarse Aggregate (C.A) (gm)	Cement (gm)	Glass Waste (gm)	Water (litre)
Sample 0	0	13.57	18.25	6.75	0	2.6
Sample 1	2.5	13.17	18.25	6.75	0.34	2.6
Sample 2	5	12.83	18.25	6.75	0.68	2.6
Sample 3	7.5	12.49	18.25	6.75	1.02	2.6
Sample 4	10	12.15	18.25	6.75	1.36	2.6

Table 1(a): Mix Ratio

Cement	F.A	C.A	Water	w/c
445.53 Kg/m^3	891.06 Kg/m^3	1202.93 Kg/m^3	153 Kg/m^3	0.4
Mix Ratio – 1:2:2.7				

Table 1(b): Mix Ratio

3.2 Variation of Slump Test

Grade Of Concrete	Sample	Value of Slump (in MM)
M30	S	75
	S1	68
	S2	60
	S3	54
	S4	45

Table 2: Slump Result

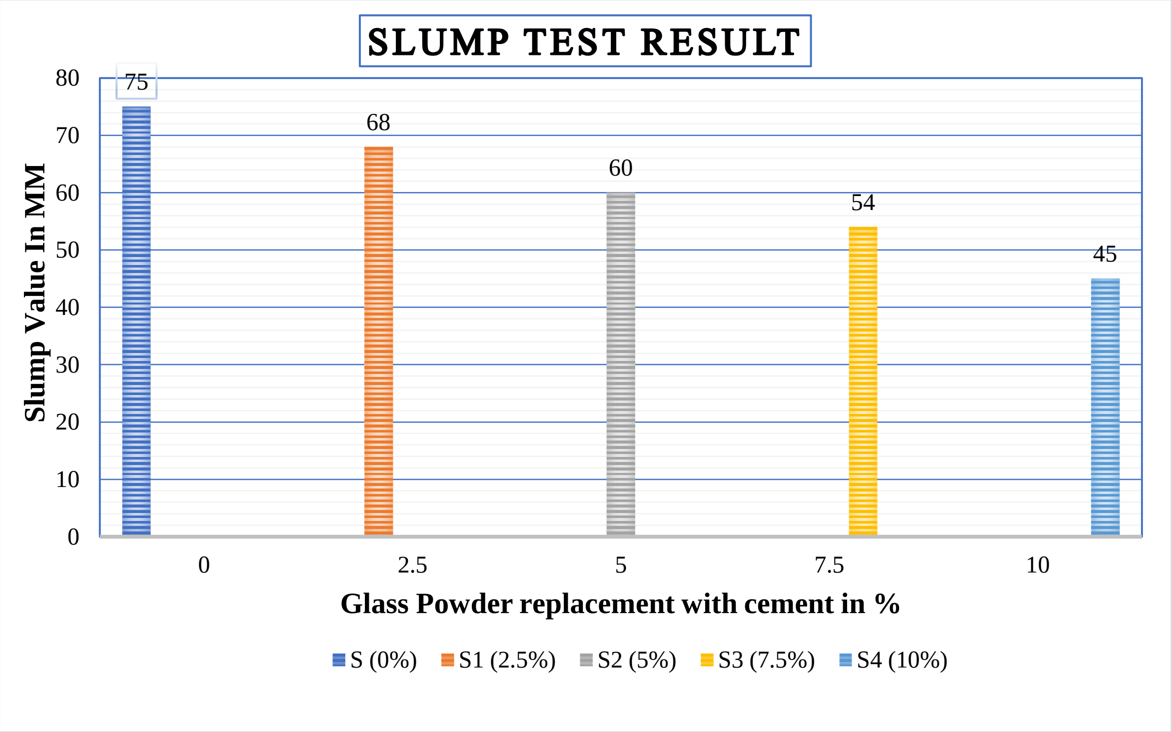

Figure 9: Graphical Representation of Variation of Slump Test

3.3 Variation of Compressive Strength

Mix designation	Glass Powder replacement with fine aggregate in %	Cube no.	7 Days compressive strength	Average 7 days strength
Sample 0	0	1	27.9	25.3
		2	20.8	
		3	27.2	

Sample 1	2.5	1	22.5	22.5
		2	23	
		3	22.2	
Sample 3	5	1	22.6	21.9
		2	20.9	
		3	22.4	
Sample 4	7.5	1	22	21.2
		2	20.5	
		3	21.3	
Sample 5	10	1	21.7	21
		2	21.1	
		3	20.3	

Table 3: Result of Compressive Strength Test After 7 Days Curing

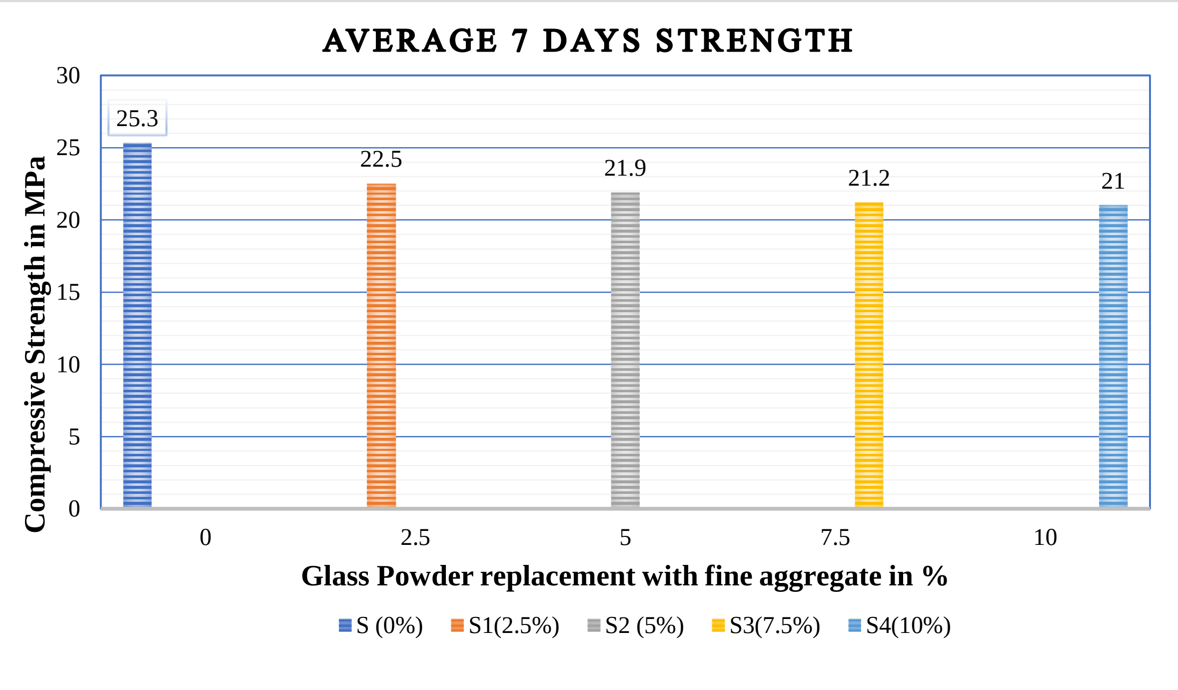

Figure 10: Compressive Strength Test after 7 Days of Curing as Shown Graphically

Mix designation	Glass Powder replacement with fine aggregate in %	Cube no.	28 days compressive strength	Average 28 days strength
Sample 0	0	1	42.3	38.6
		2	31.6	
		3	41.9	
Sample 1	2.5	1	34.7	34.6
		2	35.4	

		3	33.7	
Sample 3	5	1	34.8	33.8
		2	31.7	
		3	35	
Sample 4	7.5	1	33.4	32.6
		2	31.6	
		3	32.8	
Sample 5	10	1	32.9	32.1
		2	32.5	
		3	30.9	

Table 4: Result of Compressive Strength Test After 28 Days Curing

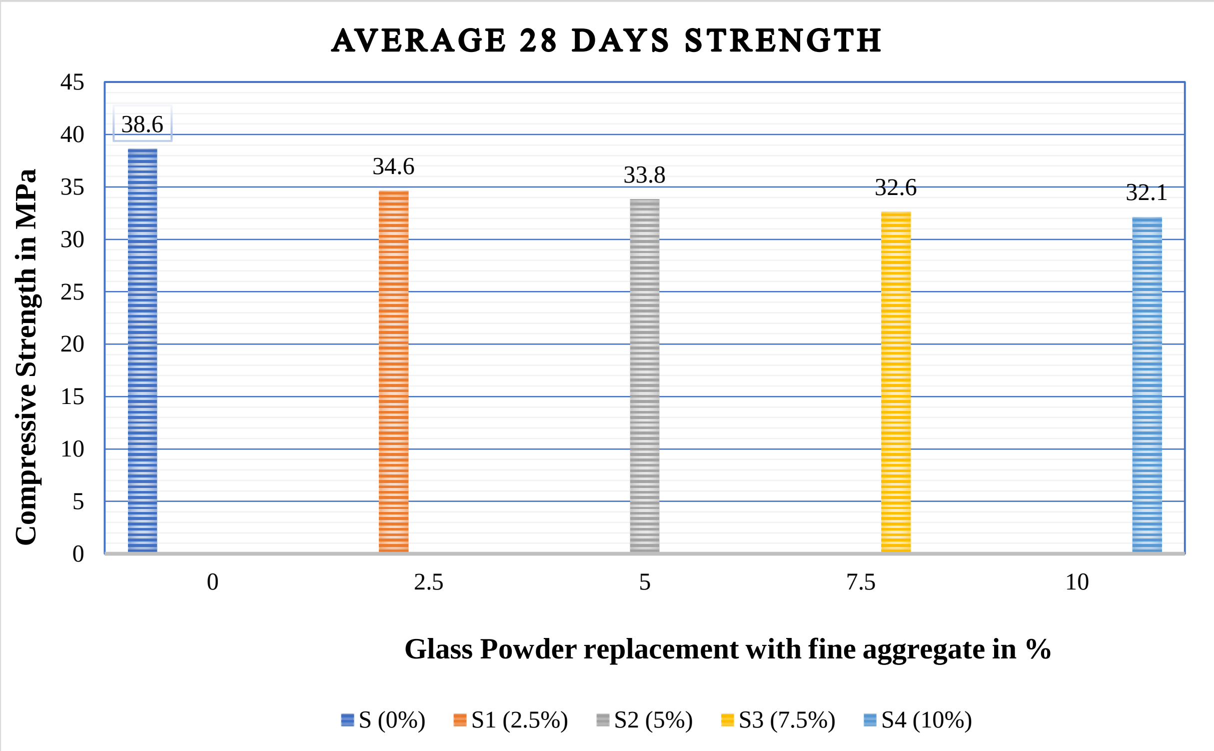

Figure 11: Graphical Representation of Compressive Strength Test After 28 Days

Sample	Compressive Strength(N/MM²)	
	7 days	28 days
S (0%)	25.3	38.6
S1 (2.5%)	22.5	34.6
S2 (5%)	21.9	33.8
S3 (7.5%)	21.2	32.6
S4 (10%)	21	32.1

Table 5: Combined Compressive Strength Result

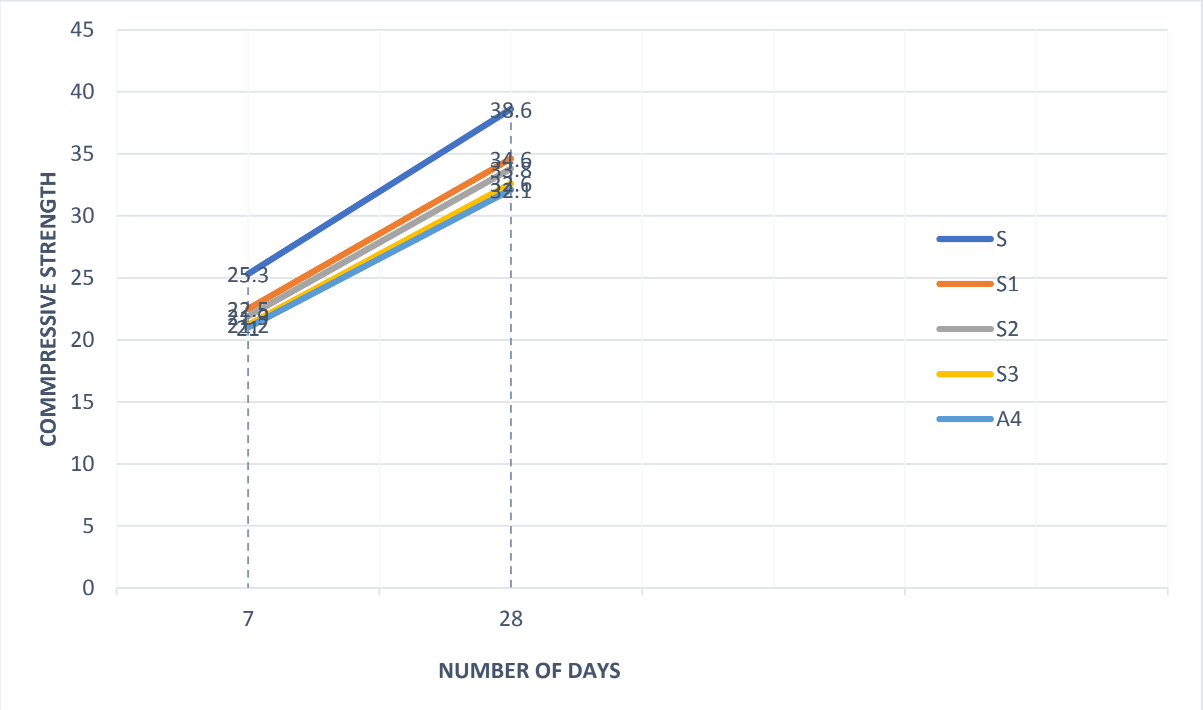

Figure 12: Graphical Representation of Combined Compressive Strength Result

3.4 Variation of Flexural Strength

Sample	Flexural Strength(N/MM²)
	28 days
S	3.74
S1	3.21
S2	3.18
S3	2.92
S4	2.85

Table 6: Result of Flexural Strength

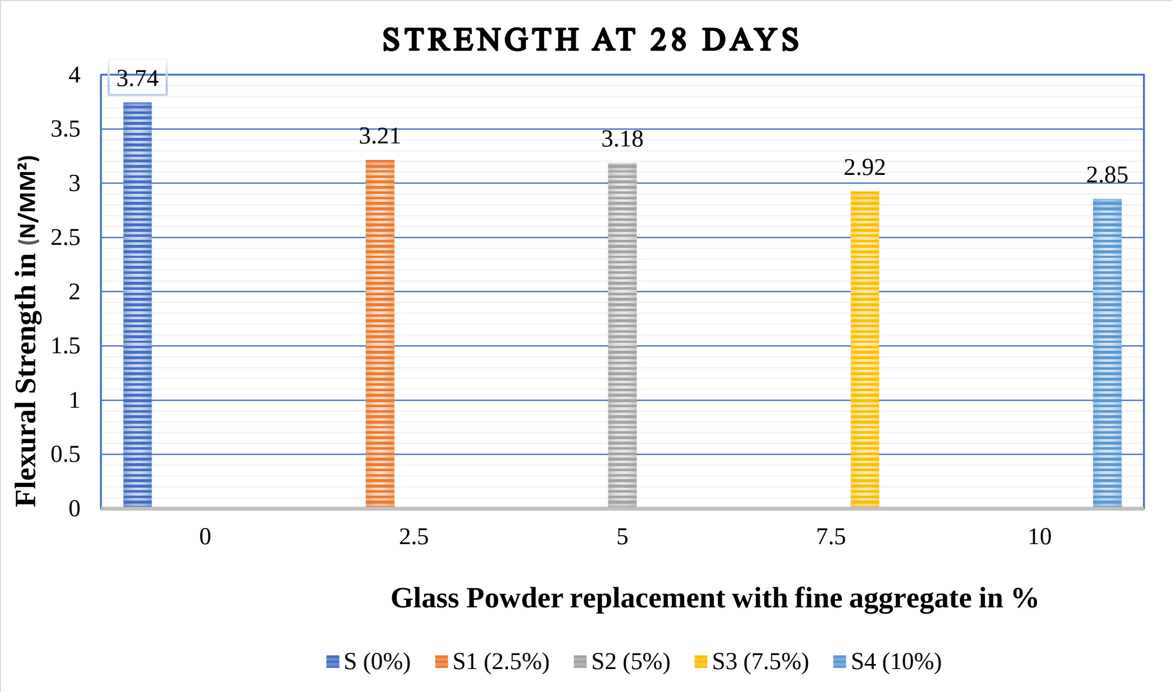

Figure 13: Graphical Representation of Flexural Strength Test

IV. Conclusion

The following conclusions are made from this experimental investigation into the compressive and flexural strength of concrete:

- While increasing the percentage of glass powder reduction in the workability is observed but the mix is workable up to a maximum replacement of 5 % at which it can be used in general construction works.
- For a replacement percentage of 7.5 % the mixture have the compressive strength of 32.6 MPa at 28 days making it reliable for compressive strength. By substituting extra percentage of glass powder, compressive strength is reduced.

- Optimum value of flexural strength is observed for a maximum replacement of 5 % blow which replacement results in loss of flexural strength.

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