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Comparative Study of Flexural Strength of M30 Grade Concrete Using Glass Powder in Comparison with Conventional Concrete

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Abstract

Aim: The study's goal is to assess the differences in flexural strength between both traditional concrete and innovative concrete based on glass particles.

Method: The experiments were divided into two groups. Each group includes 18 different specimens. The 1st group is made with addition of glass powder and the 2nd group is conventional concrete. During the preparation of concrete different types of materials and machinery is used. The pre-test power is determined with 80% and with alpha value of 0.05 and confidence interval (CI) is 95%. In concrete, fine aggregate is partially replaced by 20% of glass powder. Flexural strength test was performed on a beam specimen with flexural testing machine.

Results: Version 21 of SPSS was used to perform the independent sample t-test. Conventional concrete has a mean flexural strength of 12.9111 N/mm^2 and glass powder-based concrete with a 14.9611 N/mm^2 mean flexural strength. To assess the data, a t-test for independent samples is used. P = 0.000 ($p < 0.05$) was used to indicate significance. This shows that the two approaches have a statistically significant difference. The standard deviation is 0.66145, 0.73196, and the standard error is 0.15591, 0.17252, with the mean value being 12.91 N/mm^2, 14.77 N/mm^2.

Conclusion: The strength of the concrete's flexural component is greatly increased when new glass powder-based concrete is utilized in place of conventional concrete.

Keywords

Glass powder, M30 grade concrete, Cement, Aggregates, Flexural strength, Waste management

Introduction

The development of ultra high-performance fiber reinforced concrete, also known as ultra high-performance concrete (UHPC), is characterized by its dense microstructure, offering compressive strength exceeding 150 MPa and exceptional durability [1]. While UHPC has shown significant mechanical properties and durability improvements, especially in the rehabilitation of concrete structures, its high Portland cement and silica fume content poses cost and sustainability challenges [2].

Considering the need for sustainability alongside the enhanced properties of UHPC, exploring methods to produce UHPC with lower Portland cement content is crucial [3]. Mehta [4] has proposed three avenues for the concrete industry to achieve sustainability: reducing concrete consumption through innovative designs, minimizing Portland cement usage through smart proportioning, and increasing the volume of supplementary cementitious materials (SCMs).

In the context of optimizing UHPC mixtures, various design methods have been developed, each based on different principles, making it challenging to compare their effectiveness and resulting properties [5-9]. The first part of this study reviews existing UHPC mixture design methods, discussing their procedures, advantages, and limitations [10]. Furthermore, the use of micro- and nano-sized SCMs to partially replace Portland cement in UHPC has been extensively researched [11]. The second part of this study examines the incorporation of SCMs in UHPC mixtures [12].

A steam-heated curing process and particle packing density theory could enable UHPC to overcome an ordinary concrete's weak strength-to-weight ratio [13]. The performance of UHPC has been improved by using various types of nanomaterials. Using nanomaterials in UHPC has the advantage of improving material performance significantly with just a few nanomaterials. As binding materials or nanoscale fillers in UHPC, various types of inert and active nanomaterials have been used. In UHPC, several nanomaterials are inert, including graphite nanoplatelets, carbon nanofibers, carbon nanotubes, graphene oxide, titanium, iron oxide, and zirconia, while others are active, such as silicon, calcium carbonate, metakaolin, and alumina [13]. UHPC's packing density is influenced by the addition of nanomaterials.

The primary objective of this paper is to review significant advancements in both approaches, providing valuable scientific insights and guidance for selecting appropriate mixture design methods to achieve eco-efficient UHPC [14-16]. This entails a new material that retains the outstanding mechanical behavior of UHPC while meeting sustainability criteria.

Materials and Method

The experiments were split into two groups. Conventional concrete of M30 grade was used in one group of concrete specimens, as per Indian Standards (IS) criteria, whereas 20% glass powder was combined with concrete, cement, aggregate, and water in the further sets of concrete examples. Figure 1 materials used in concrete preparation. Figure 2a casting of the beam in mold. Figure 2b workability test. Figure 2c curing process of the concrete beam. Figure 3 a tensile testing machine.

The G-power software has computed the sample size and found that with 18 samples in each group, a total of 36 tests can be conducted. The independent t-test computation is done using 80% G-power The SPSS (version 21) program can be used to perform statistical analysis on comparative research.

To test the concrete's strength, 100 x 100 x 500 mm concrete cubes were cast. Group 1 was defined as having a 20% replacement of fine aggregate with new glass powder. Ramco cement (OPC 53 grade) specifications: specific gravity of 3.15 reliability of 31.5% beginning setting time of 30 min, ultimate setting time of 600 min, and soundness level 2 were applied. Used as a fine aggregate was locally accessible M-sand that passes through a 4.75 mm sieve and has a specific gravity of 2.63 and a fineness modulus of 2.74. In the project, the coarse aggregate of 20 mm size of the sieve pass-through 80 mm, 40 mm, 20 mm, etc., is utilized, which is crushed stone from a quarry that is split into small pieces and has an irregular shape. The parameters of cement are shown in table 1, and the characteristics of fine and coarse aggregate are shown in table 2 and table 3.

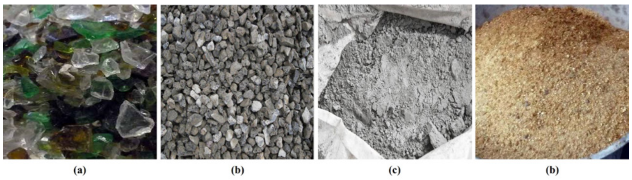

Figure 1: Materials used in concrete preparation. **(a)** Waste glass, **(b)** Coarse aggregate, **(c)** Cement, and **(d)** Fine aggregate.

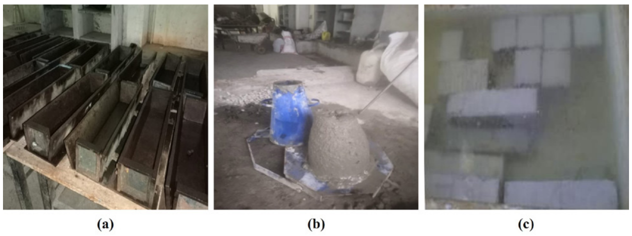

Figure 2: **(a)** Casting of the beam in mold, **(b)** Workability test, and **(c)** Curing process of the concrete beam.

Figure 3: The data on flexural strength were collected using a tensile testing machine.

Table 1: Properties of cement.

S. No.	Properties	Result
1	Fineness	90 micron
2	Particular gravity	3.15
3	Typical consistency	31.5%
4	First configuration	30 min
5	Last configuration	600 min

Table 2: Properties of fine aggregate.

S. No.	Properties	Result
1	Size of sample	4.75
2	Sieve analysis	2.59
3	Water absorption	3%
4	Specific gravity	2.65

Concrete for group 1 is manually batch-mixed with the necessary components before being prepared for the sample specimen. Regular M30-grade concrete is added directly and

Table 3: Properties of coarse aggregate.

S. No.	Name of the test	Result
1	Size	20 mm
2	Sieve analysis	20 mm
3	Water absorption	3.14%
4	Specific gravity	2.68

uniformly. Three equal-height layers of this concrete were poured into the mold, and each layer was tamped 25 times. To eliminate any gaps in the specimen, vibration is often used during the casting process. Following sample preparation, the specimens were kept at room temperature for seven people 28 days to cure.

Identical procedures were followed for group 2, with the exception that 20% glass powder relative the amount of cement that was applied when blending the concrete. The flexural strength of 18 group 1, or conventional, specimens, was determined after testing. Similar to this, the flexural strength of 18 specimens of group 2, or glass powder used concrete examples, was determined.

Statistical analysis

The concrete's flexural strength grade, the number of curing days for the water cement, and the analytical differences factors were treated as independent variables for the analysis, which was conducted using the SPSS (version 21) program. Each sample t-test was run separately to determine the study's analytical variance variable. The standard deviation and standard error of the mean for flexural strength were calculated using this software.

Results

The average strength of nominal concrete was 34.2744 N/mm^2, while glass powder concrete had a flexural strength of 35.4978 N/mm^2. The standard deviation of conventional concrete's flexural strength was 1.6697, while that of glass powder concrete was 2.1529. Table 4 flexural strength of conventional concrete. Table 5 flexural strength of glass powder. Table 6 represents group statistics for both sample groups.

The flexural strength results of 18 specimens are shown in table 7 along with the importance of flexural strength as defined by the result of Levene's test for variance equality was 0.254. Table 7 displays the independent samples t-test findings. With a 95% error bar and a 0.05 p-value, figure 4 compares the mean accuracy values for two groups of conventional concrete and new glass powder concrete, error graphs with a ± 1 standard deviation mean accuracy detection error.

Table 4: Flexural strength of conventional concrete.

Mix type	Flexural strength for 28 days (N/mm^2)	Average flexural strength for 28 days (N/mm^2)
Conventional concrete	13.4	12.91
	13.7	
	13.6	
	13.5	
	13.1	
	11.4	
	12.8	
	12.1	
	13.7	
	12.5	
	12.7	
	13.6	
	12.5	
	12.2	
	12.2	
	13.4	
	12.9	
	13.1	

Table 5: Flexural strength of glass powder concrete.

Mix type	Flexural strength for 28 days (N/mm^2)	Average flexural strength for 28 days (N/mm^2)
Modified concrete	14.7	14.77
	15.3	
	15.6	
	15.1	
	14.2	
	14.02	
	14.33	
	15.7	
	14.2	
	15.53	
	14.02	
	15.2	
	14.12	
	14.32	
	13.43	
	15.89	
	14.65	
	15.63	

Table 6: Represents group statistics for both sample groups. Mean (12.91,14.77), standard deviation (0.66145,0.73196), and standard error mean (0.15591,0.17252).

Group	N	Mean	Std. deviation	Std. error mean
Conventional concrete	18	12.91	0.66145	0.15591
Glass powder concrete	18	14.77	0.73196	0.17252

Discussion

Waste reduction and enhanced sustainability of building materials and waste management have been researched through the partial replacement of fine aggregate in concrete with glass powder. Research has shown that replacing a portion of the fine aggregate with glass powder can result in improved workability and flexural strength of the concrete, while also reducing its permeability. Hence, using glass powder in concrete may also result in a decrease in flexural strength, increased shrinkage and cracking, and reduced durability.

Ultimately, the use of glass powder in place of fine aggregate in concrete relies on the particular circumstances and

Table 7: For the two groups, an independent sample t-test is conducted to determine the strength of the significant difference observed, with a p-value of 0.000 being less than ($p < 0.05$). This demonstrates that the two approaches differ statistically significantly.

Load	Levene's test for equality of variances		T-test for equality of means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% CI of the difference	
								Lower	Upper
Equal variance assumed	0.716	0.403	-8.013	34	0.000	-1.86333	0.232	-2.3359	-1.3907
Equal variance not assumed	-	-	-8.013	33.65	0.000	-1.86333	0.232	-2.3360	-1.3905

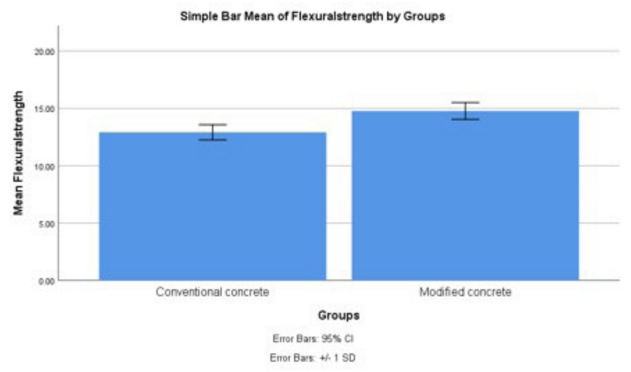

Figure 4: The average flexural strengths of 20% glass powder concrete and conventional concrete is analysed using a bar chart. 20% sand replaced with glass powder shows better accuracy compared to conventional concrete. The Y-axis shows mean flexural strength, the X-axis the group sample, and the mean detection accuracy is ± 1 standard deviation.

demands of the project, and additional research is required to fully comprehend both its potential advantages and disadvantages. Ultimately, the use of glass powder as a substitute for fine aggregate in concrete depends on the particular circumstances and demands of the project, and additional research is required to fully comprehend both its potential advantages and disadvantages. Before considering glass powder as a replacement, it is important to carefully evaluate its potential impact on the properties of the concrete and to consider the cost and availability of alternative materials.

This process costs more when compared to the normal or conventional mix of concrete, while the mixing process needs more care of hands, especially in the process of manual mixing, and the availability of the proper admixture is difficult when compared to conventional concrete. The primary objective of a construction waste management strategy is to decrease the amount of materials that are disposed of during construction, which involves removing land-clearing debris, demolition waste, and construction waste from landfills.

The modified concrete technology will help to get higher strength of the concrete, it is a replacement for traditional concrete. Suitable for water resistance and high-temperature resistance.

Conclusion

Comparing innovative glass powder concrete of M30 grade to traditional concrete, the average increase in flexural strength was 1.86 N/mm^2, according to a comparative analysis. Glass powder concrete has an average strength of 12.91 N/mm^2. Whereas conventional concrete had a mean compressive strength of 14.77 N/mm^2. Hence as per flexural strength result glass powder mixed concrete can achieve good results.

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None.

Conflict of Interest

None.

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