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Experimental Study on Compressive Strength of M30 Grade Concrete Using Waste Glass Powder in Comparison with Conventional Concrete

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Abstract

The aim of this study is to compare glass powder based M30 concrete to conventional concrete in terms of compressive strength. 18 samples were divided into two groups and prepped for data collection. The first is made using glass powder in place of fine aggregate, and the second is regular concrete. The preparation and examination of the samples involved using a variety of tools and materials. The pretest power is determined with 80% confidence intervals (CI) are 95% respectively. The 20% of glass powder was partially replaced in fine aggregate. Utilizing the universal testing machine, compression strength tests were conducted. The independent sample t-test was carried out using SPSS (Statistical Package for the Social Sciences) software, version 21. The mean compressive strength of concrete with innovative glass powder was 35.4978 N/mm^2, whereas the typical mean compressive strength of conventional concrete is 34.2744 N/mm^2. A t-test for independent samples is used to analyze the findings. The significance was $p = 0.000$ ($p < 0.05$). This demonstrates that the two approaches have a statistically significant difference. The standard deviation is 1.6697, 2.1529, and the standard error is 0.3935, 0.5074, with the mean value being 34.2744 N/mm^2, 35.4978N/mm^2. From this experimental study, the innovative glass powder based M30 grade concrete is found to have a higher compressive strength than regular concrete, it is determined.

Keywords

Glass powder, Cement, Aggregate, Compressive strength, M30 grade, Conventional concrete, Waste management

Introduction

Fine aggregate is a crucial component in the creation of concrete, and its characteristics have a significant impact on the strength and durability of the structure [1]. Due to its advantages for the environment and potential to improve concrete's functionality, using glass powder in place of fine aggregate has drawn attention recently. Glass powder, a by-product of the glass industry, is obtained by crushing, grinding, and sieving of waste glass. Its fine particle size and angular shape make it an excellent candidate for partial replacement of fine aggregate [2].

About 3,600 results from Google Scholar, lead to this type of alternate material in addition to concrete and reduce the environmental impact by researchers. There have been roughly 670 articles on this subject in Google Scholar and 340 in Science Direct over the past five years. In a study on the strength parameters of concrete using fine aggregate as a partial replacement for M30 grade concrete, copper slag and glass powder were utilized [3]. In these research papers, they did for novel glass powder concrete moderately replaces fine aggregate [4]. Among all of these methods, nanomaterials have gained the most attention due to their ex-

traordinary ability to repair concrete flaws, especially improving the strength development at early ages. Almost all samples containing nano-glass powderexhibited higher strength performance compared to the control sample [5].

As a result of the research, 20% of the fine aggregate in M30 grade concrete is replaced with glass powder. This concrete combination increases the strength values, and an experiment was set up to determine the outcome of such combinations. By effectively utilizing these by-products, the use of such materials not only contributes to the conservation of natural resources but also helps in preserving favorable environmental conditions. The primary purpose of a construction waste management strategy is to redirect construction trash, demolition debris, and habitat destruction debris from landfilling in order to limit the number of materials discarded during development.

Materials and Method

The experiments were split into two groups. One category of concrete is M30 grade conventional concrete was made in accordance with IS requirements, whereas other groups of concrete examples were constructed using concrete that had 20% glass powder mixed in together with M30-grade cement, aggregate, and water. The G-power has estimated the sample size. and each group has 36 tests that can be run on 18 samples. The paired t-test computation is done using 80% G-power. To test the concrete's strength, 150 x 150 x 150 mm concrete cubes were cast.

Concrete classified as group 1 is standard concrete. Ramco cement, grade OPC 53, with the following characteristics 30 min initial setting, 31.5% consistency, 3.15 specific gravity, 600 min final setting, and 2.8 soundness. Fine aggregate was locally accessible 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, a 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. Table 1 indicates the properties of cement, and table 2 and table 3 show the property of fine and coarse aggregate.

Concrete for group 1 is manually batch-mixed with the essential components before even being ready for the sample specimen. Normal M30 grade concrete is added straight and evenly. Three equal-height layers of this concrete were poured into the mold, and each layer was compressed 25 times. During the casting process, vibration is frequently utilized to remove gaps from the specimen. Following sample preparation, the specimens were kept at room temperature for curing for 7 and 28 days.

Identical procedures were followed for group 2, with the only exception that during the concrete mixing process, 20% glass powder was added relative to the volume of cement. The compressive strength of 18 group 1, or conventional specimens, was determined after testing. Corresponding to this, the compressive strength of 18 group-2 specimens of glass powder-infused concrete was determined.

Table 1: Properties of cement.

S. No.	Properties	Results
1	Fitness	90 microns
2	Specific gravity	3.15
3	Standard consistency	31.5%
4	Initial setting	30 min
5	Final setting	600 min

Table 2: Properties of fine aggregate.

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

Table 3: Properties of coarse aggregate.

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

Statistical analysis

The study's independent variables comprised the concrete's compressive strength grade, water cement curing days, and analytical differences factors. These were all calculated using SPSS (version 21) software. To pinpoint the study's analytical differences variable, independent sample t-tests were used. This program also calculated the compressive strength's standard deviation and standard error of the mean. An independent sample t-test done for both groups is not statistically significant when there is a significant difference between the two groups and the g power is 80% and $p = 0.000$ ($p > 0.05$). The compressive strength of glass powder addition concrete is compared to conventional concrete.

Results

Figure 1 shows materials used in concrete preparation. (a) waste glass, (b) coarse aggregate, (c) cement, and (d) fine aggregate. Figure 2 shows (a) casting of the cube in mold, (b) mixing of glass powder, and (c) workability test. Figure 3 shows universal testing machine. Figure 4 shows a broken specimen has been observed after conducting a test on a universal testing machine, which is a device designed to measure the physical and mechanical properties of materials, such as strength, elasticity, and toughness. Figure 5 shows the analysis of the mean compressive strength of conventional concrete and concrete with 20% glass powder-based concrete is shown in a bar chart. 20% replacement of glass powder in concrete shows better accuracy compared to conventional concrete. The X-axis shows the group sample, the Y-axis shows the mean compressive strength, and the average detection accuracy is +/- 1 standard deviation.

Table 4 presents results of compressive strength of conventional concrete (M30 grade). Table 5 presents results of



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 cube in mold, **(b)** Mixing of glass powder, and **(c)** Workability test.



Figure 3: The data on compressive strength were collected using a universal testing machine.



Figure 4: A broken specimen has been observed after conducting a test on a universal testing machine, which is a device designed to measure the physical and mechanical properties of materials, such as strength, elasticity, and toughness.

compressive strength of the modified concrete (M30 grade). Table 6 represents group statistics for both sample groups. Mean (34.2744,35.4978), standard deviation (1.6697,2.1529), and standard error mean (0.3935,0.574). The mean compressive strength of novel glass powder-based concrete was

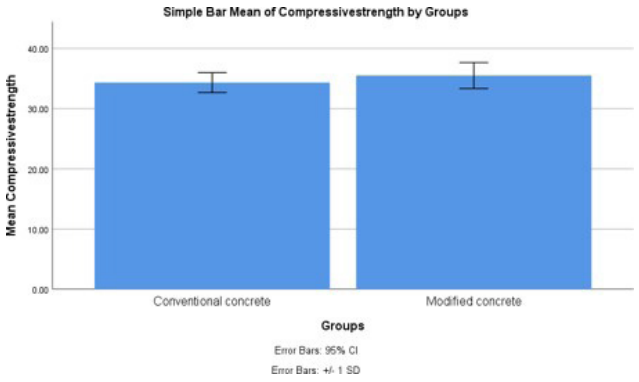


Figure 5: Analysis of the mean compressive strength of conventional concrete and concrete with 20% glass powder-based concrete is shown in a bar chart. 20% replacement of glass powder in concrete shows better accuracy compared to conventional concrete. The X-axis shows the group sample, the Y-axis shows the mean compressive strength, and the average detection accuracy is +/- 1 standard deviation.

Table 4: Result of compressive strength of conventional concrete (M30 grade).

S. No.	Weight (Kg)	Load (kN)	Compressive strength (N/mm²)
1	8.132	590	30.67
2	8.543	672	34.31
3	8.231	659	33.73
4	8.987	680	34.67
5	9.011	674	34.40
6	8.654	685	34.89
7	8.256	725	32.22
8	8.987	689	35.07
9	9.231	617	31.87
10	8.765	693	35.24
11	9.043	662	33.87
12	8.798	653	33.47
13	8.675	696	35.38
14	8.793	699	35.38
15	9.045	720	36.44
16	8.894	650	33.33
17	9.406	597	35.42
18	9.654	746	37.60
Mean compressive strength			**34.2744**

35.4978 N/mm² and mean conventional concrete's strength was 34.2744 N/mm². The standard variation of conventional concrete's compressive strength was 1.6697 while that of novel glass powder concrete had a standard deviation of 2.1529. The SPSS software carried out significance was p = 0.000 (p > 0.05). This shows that there is a statistically significant difference between the two methods. The compressive strength readings for 18 samples are shown in table 7, along with the significance of compressive strength determined by Levene's test for variance equality, which was 0.254. The 18 samples' compressive strength values made without conventional concrete are shown in table 4.

Table 5: Result of compressive strength of the modified concrete (M30 grade).

S. No.	Weight (Kg)	Load (kN)	Compressive strength (N/mm²)
1	9.126	752	34.23
2	8.861	824	36.45
3	8.621	790	32.12
4	9.072	852	35.78
5	8.672	733	33.67
6	8.528	885	36.44
7	8.948	721	31.89
8	8.765	923	38.84
9	9.172	863	37.22
10	8.972	752	33.97
11	8.894	963	39.55
12	9.192	812	37.32
13	8.894	722	32.75
14	8.724	835	35.63
15	8.979	863	35.18
16	8.754	783	34.63
17	9.152	890	37.02
18	8.852	836	36.27
Mean compressive strength			**35.4978**

Table 6: Represents group statistics for both sample groups. Mean (34.2744,35.4978), standard deviation (1.6697,2.1529), and standard error mean (0.3935,0.574).

	Groups	N	Mean	Std. deviation	Std. error mean
Compressive strength	Conventional concrete	18	34.2744	1.6697	0.3935
	Glass powder concrete	18	35.4978	2.1529	0.5074

Table 7 displays the outcomes of the independent samples t-test. A 95% error bar and a p-value of 0.05 are used in figure 5 to compare the average accuracy values of conventional concrete and glass powder concrete in two groups. With a mean detection accuracy error of +/- 1 standard deviation, error bars are used.

Table 7: Independent sample t-test t is performed for the two groups the significant difference observed for strength in an independent sample t-test p = 0.000 as it is less than p = 0.05. This shows that there is a statistically significant difference between the two methods.

Compressive strength	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	1.348	0.254	-1.905	34	0.000	-1.2233	0.6421	-2.5284	-0.08173
Equal variance not assumed	-	-	-1.905	32.018	0.000	-1.2233	0.6421	-2.5313	-0.08471

Discussion

There has been research done on using glass powder to replace some of the fine aggregate in concrete. as a means of lowering waste and raising the sustainability of building supplies and trash disposal [4]. Research has shown that replacing a portion of the fine aggregate with glass powder can result in improved workability and compressive strength of the concrete, while also reducing its permeability [6]. The use of glass powder, however, can also result in the concrete having a lower flexural strength, more shrinkage and cracking, and a shorter lifespan.

Overall, the effectiveness of glass powder concrete as a substitute for fine aggregate depends on the specific conditions and requirements of the project, and more research is needed to fully understand its potential benefits and limitations. 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. By preventing construction trash, demolition waste, and land clearing debris from being disposed of in landfills, a construction waste management strategy generally aims to reduce the number of materials disposed of there during construction.

Conclusion

The glass powder-based concrete has a mean compressive strength of 35.4978 N/mm^2. Whereas conventional concrete had a mean compressive strength of 34.2724 N/mm^2. The compressive strength of glass powder-based powder M30 grade concrete increased by 1.2254 N/mm^2. As a result, the glass powder boosts the concrete's compressive strength when it is put to concrete as a partial replacement for fine aggregate.

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None.

Conflict of Interest

None.

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