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Analyzing Effect of Waste Glass Powder in Concrete by Partial Replacement of Cement

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Abstract:
The research work was carried out to analyze the effect of waste glass powder in various concrete grades by partial replacement of cement. In this study OPC was replaced partially with waste glass powder at 5%, 10%, 15% and 20% by weight of the cement in three different grades of concrete M20, M25 and M30 and tested for compressive strength at 7th, 28th and 56th days and the results were compared with those of conventional concrete. The results show enhancement in the compressive strength added with waste glass powder as partial replacement of cement.

Key Words: Concrete, waste glass powder, compressive strength.

1. Introduction:

Concrete is the combination of various materials i.e. coarse aggregate, fine aggregate, cement & water, each of them is mixed in various proportions to achieve specific strength. Cement being the most important material plays an important role in the manufacturing of concrete. Cement possesses binding properties and provides strength. The concrete consumes various non-renewable sources & their consumption increases the threat of sustainable concrete. The concrete is the most widely used material in construction industry and the cement is the main constituent of concrete and contributes to release the CO_2 during the production of cement. The cement manufacturing industry is one of the carbon emitting sources. As per studies one ton of carbon dioxide is released into the atmosphere for every one ton of cement, which contributes approximately 7% of the word's total yearly production of CO_2. The cement is the common construction material in India and its production causes environmental concerns. The cement industry is facing various problems such as to reduce the CO_2 emission, increase cost energy supply and requirement of natural non- renewable raw materials. In order to address environmental effects due to cement manufacturing, there is a need to develop alternative binder to make concrete. As a result wide researches are going on into the use of cement replacements, using many waste materials and industrial by products. Efforts have been made in the concrete industry to use waste glass as partial replacement of fine or coarse aggregates and cement.

On the other hand, the amount of glass wastes generated every year is quite high. Glass packing industries produce thousand million tons of bottles every year as per studies in India and 0.7% of total urban waste generated is glass waste. The glass is non-biodegradable material which is not suitable for land fill. Glass can be recycled but first need to be sorted as this is an expensive process.

The energy required to reuse the recyclable material is less than that of virgin materials. Glass is a common product that can be found in different forms: bottles, jars, windows and windshields, bulbs, cathode ray tubes etc. These products have a limited lifetime and generally disposed off after its usage. The current practice is still to landfill most of the non-recyclable glass. Since glass is a non biodegradable material, these landfills do not provide an environmental solution and must be recycled in order to overcome environmental problems related to their stockpiling or land filling. Utilization of waste glass has attracted construction industry due to its probable utilization in concrete. Use of waste glass as aggregate in concrete has been attempted by many investigators.

In my study, finely powdered with size less than 75µm plain windows waste glass is used as a partial replacement of cement in various concrete grades and compared it with conventional concrete grades. This work analyzes the possibility of using Glass powder as a partial replacement of cement for new concrete. Cement was partially replaced with glass powder at5%, 10%, 15% and 20% by weight of the cement and tested for its compressive strength at7days, 28 days and 56 days and was compared with conventional concrete. From the results obtained, it was found that glass powder can be effectively used as cement replacement.

2. Objective:

Experiments were conducted to analyze the effect on concrete, when cement is partially replaced by waste glass powder. The main objective of this research was to assess the Compressive strength of concrete when partially replaced by the waste glass powder of size 75µm down The specimens of cubes were cast by partially replacing cement with waste glass powder by 5%, 10%, 15%, and 20% for three different grades of concrete i.e. M20, M25 and M30. The results obtained from test were compared with conventional concrete

3. Experimental Procedure

3.1 Materials Used

3.1.1 Cement

The OPC -43 grade Ultra-Tech conforming to IS code (BIS: 8112) was used having following physical properties:

Table No 1: Physical Properties of Cement (OPC-43 grade)

Sr.No.	Description	Values Obtained	Requirements as per IS 8112-1989
1	Standard Consistency (using Vicat Apparatus)%	32	--
2	Initial Setting Time (Min)	65	>30 Mins
3	Final Setting Time (Min)	435	<10hrs
4	Specific Gravity (Specific Gravity Bottle)	3.15	3.0-3.15

3.1.2 Glass Powder

The waste glass used in the experiments was plain clear glass of windows and doors collected from the campus of NITTTR Chandigarh, which was crushed and ground into powder mechanically by pulverizer which was sieved and passed through IS sieve 75µm size in NITTTR lab and the following physical properties of waste glass powder were obtained:

Table No 2: Physical Properties of waste glass powder

Properties	**Results**
Specific Gravity	2.6
Fineness passing 75µm	99 %
Colour	White

3.1.3 Coarse Aggregate

In the experimental studies the coarse aggregate used were crushed angular conforming to BIS 383-1970 of size 20mm to 10 mm mixed in proportion of 1.5:1 ratio with specific gravity 2.71.

3.1.4Fine Aggregate

The locally available sand conforming to Zone –III having the specific gravity of 2.64 conforming to IS code 383-1970 was used.

3.1.5 Water

In this investigation, the tap water was used, water used in concrete work should be free from foreign matters or injurious amount of soils, acids, alkalis or other organic, inorganic impurities. It should be free from iron, vegetable matters or any other type of substances, which are likely to have adverse effect on concrete; it should be fit for drinking purposes.

3.2 Experimental Plan

In this study, OPC was replaced by waste glass powder by 5%, 10%, 15% and 20% for M20, M25 and M30 grade concrete. Total 135 numbers of Cube specimens of size 150mm x150mm x 150mm were cast out of which 108 numbers were for partial replacement of cement with waste glass powder and 27 numbers of cubes for conventional concrete. The test was carried out for Compressive strength and compared with conventional concrete of respective grade.

3.3 Design Mix.

Concrete mix design of M20, M25 and M30 was carried out conforming to BIS: 10260-2009. The material ratios as per design are given in table No 3.

Table No 3: Material ratios.

Grade of Concrete	W/C ratio	Materials		
		Cement	Fine Aggregate	Coarse Aggregate
M20	0.50	1	2.19	3.98
M25	0.45	1	1.69	3.21
M30	0.42	1	1.64	3.19

3.4 Testing

3.4.1 Compressive Strength Test

The specimen cube of size 150mm x150mm x 150mm were cast and the compressive test was carried out as per IS: 516-1959 at 7^{th}, 28^{th} and 56^{th} days using compression testing machine of capacity 3000KN.The results obtained are shown in Table No 4, Table No 5 and Table No 6 and Figure No1, Figure No2 and Figure No3 show the Compressive strength gain on various percentages of glass powder when tested at 7^{th}, 28^{th} and 56^{th} day.

Fig. No. 1 Compressive Strength of M20 Grade V/S %age of Glass Powder

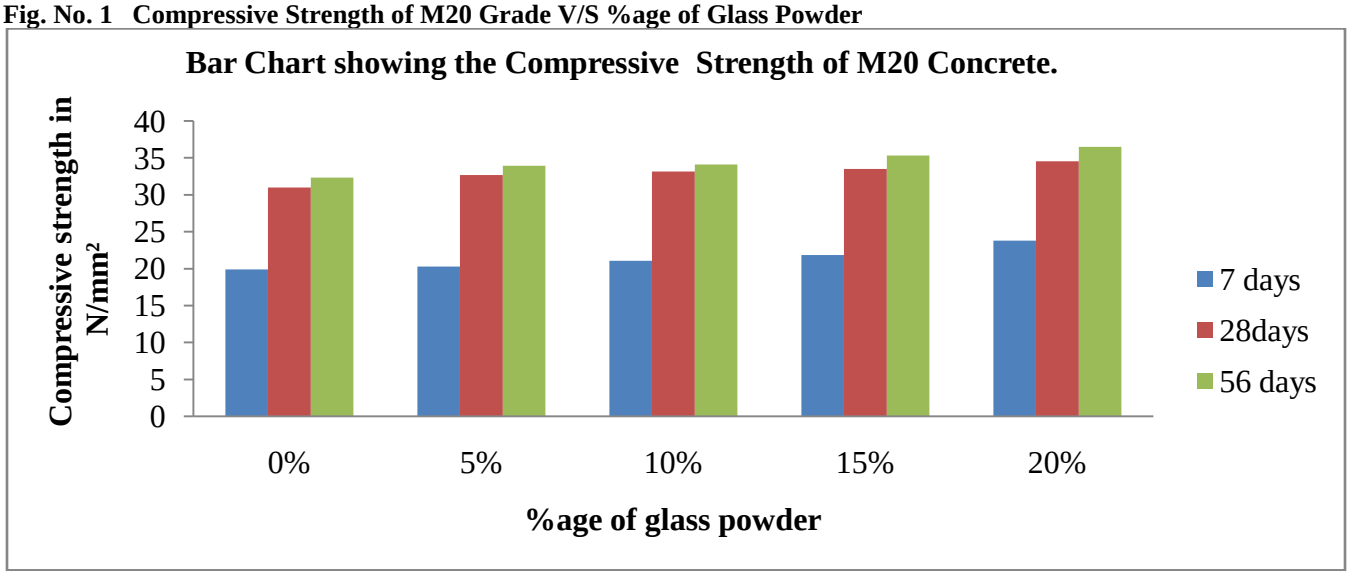

Table No. 4:

Result of Cube (Grade M20) Compressive Strength in N/mm²						
% of Glass Powder	Compressive strength in N/mm²			Average compressive strength in N/mm²		
	After7 days	After28days	After56days	After7 days	After28days	After56days
0%	20.0	32.0	33.00	19.90	31.00	32.33
	19.5	30.0	30.00			
	20.2	31.0	34.00			
5%	20.2	32.2	34.50	20.27	32.67	33.93
	21.0	32.8	33.60			
	19.6	33.0	33.70			
10%	21.0	32.0	33.00	21.07	33.17	34.10
	20.2	34.0	35.10			
	22.0	33.5	34.20			
15%	21.5	31.5	33.10	21.83	33.50	35.30
	23.0	35.0	37.00			
	21.0	34.0	45.00			
20%	22.0	33.6	34.90	23.80	34.53	36.5
	23.4	34.0	36.10			
	26.0	36.0	38.50			

Fig. No. 2 Compressive Strength of M25 Grade V/S %age of Glass Powder

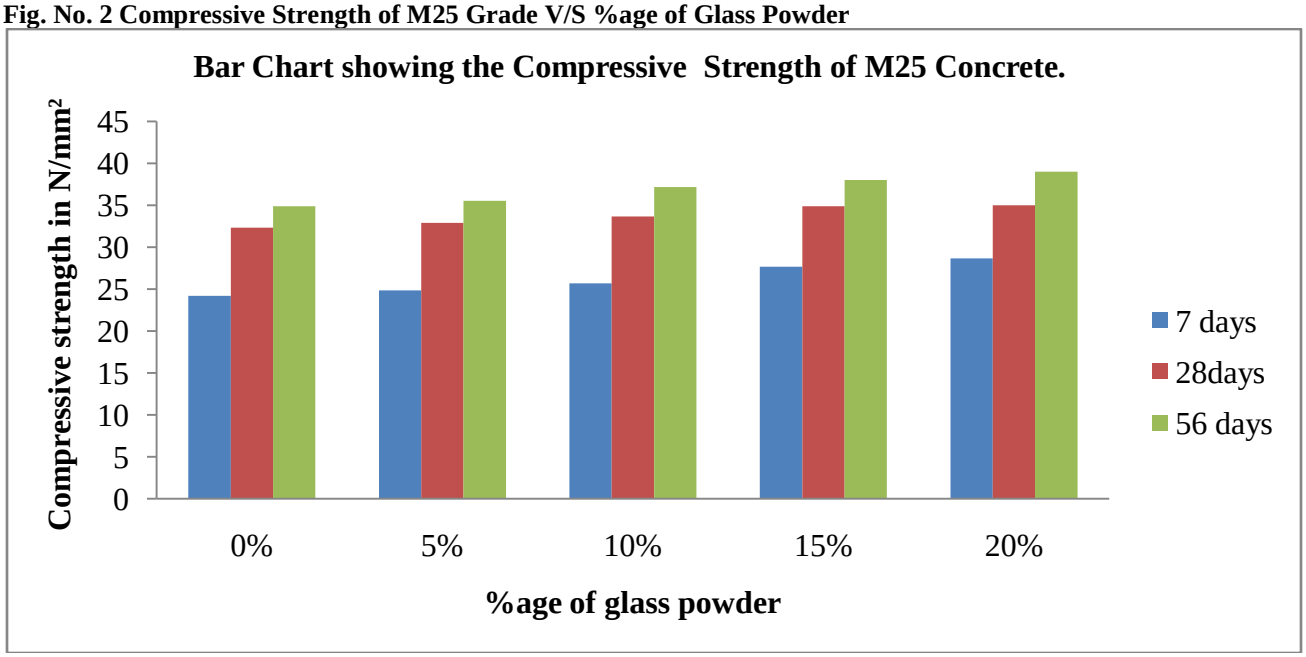

Table No. 5

Result of Cube (Grade M25) Compressive Strength in N/mm²						
% of Glass Powder	Compressive strength in N/mm²			Average compressive strength in N/mm²		
	After 7 days	After28days	After56days	After7days	After28days	After56days
0%	25	33	34	24.2	32.33	34.87
	24	30	36			
	23.6	34	34.6			
5%	24.8	33.2	34.6	24.83	32.90	35.53
	24.5	32.5	35			
	25.2	33	37			
10%	25.6	33	35.5	25.70	33.67	37.17
	24.5	36	36			
	27	32	40			
15%	25	34	38	27.67	34.87	38.00
	30	34.6	36			
	28	36	40			
20%	28	35	38	28.67	35.00	39.00
	26	36	40			
	32	34	39			

Fig. No.3 Compressive Strength of M30 Grade V/S %age of Glass Powder

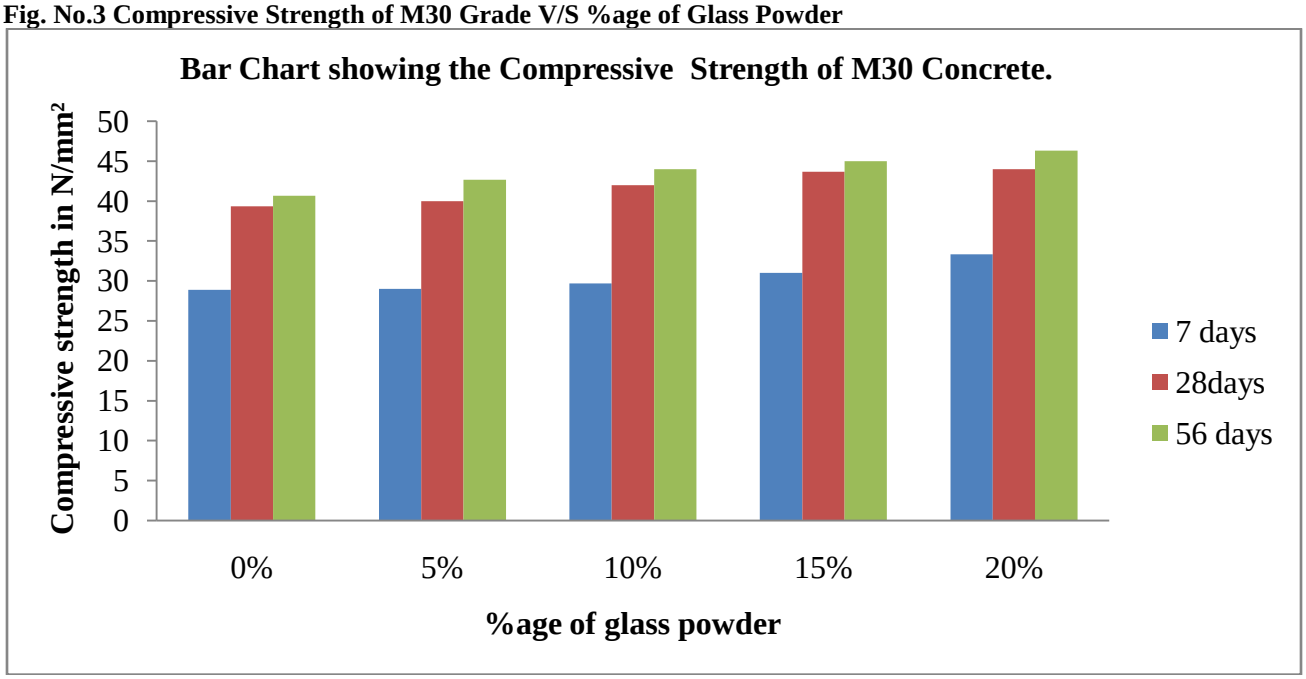

Table No. 6

Result of Cube (Grade M30) Compressive Strength in N/mm²						
% of Glass Powder	Compressive strength in N/mm²			Average compressive strength in N/mm²		
	After 7 days	After28days	After56days	After7days	After28days	After 56 days
0%	30	39	40	28.87	39.33	40.67
	28	37	38			
	28.6	42	44			
5%	29	36	42	29.00	40.00	42.67
	32	44	46			
	26	40	40			
10%	28	46	46	29.67	42.00	44.00
	32	42	44			
	29	38	42			
15%	33	48	49	31.00	43.67	45.00
	32	45	44			
	28	38	42			
20%	34	46	52	33.33	44.00	46.33
	36	42	45			
	30	44	42			

4. Results and discussion:

The effect of glass powder on the compressive strength of concrete has been studied in this research. The test was performed for three grades of concrete M20, M25 and M30 by replacing cement with waste glass powder by 5%, 10%, 15% and 20% and results on7th. 28th and 56th day was observed.

For conventional concrete of M20 it was 19.90, 31.0 and 32.33N/mm^2 respectively. With 5% cement replacement was20.27, 32.67 and 34.67 N/mm^2 respectively. With 10% replacement, the result was 21.07, 33.17 and 34.87N/mm^2 respectively. With 15% replacement, the result was 21.83, 33.50 and 39.0 N/mm^2 respectively, and by replacing 20% cement result was 23.8, 34.53 and 42.67 N/mm^2 respectively.

For conventional concrete of M25 it was 24.2, 32.33 and 34.87 N/mm^2 respectively. The results with 5% replacement were 24.83, 32.9 and 35.53N/mm^2 respectively. With 10% replacement, it was 25.70, 33.67 and 37.17N/mm^2 respectively. With 15% replacement, it was 27.67, 34.80 and 38.0 N/mm^2 respectively and for 20% replacement result was 28.67, 35.00 and 41.33N/mm^2 respectively.

For conventional concrete of M30 the result was 28.87, 39.33 and 40.67 N/mm^2 respectively. With 5% replacement, the result was 29.0, 40.0and 42.67 N/mm^2 respectively. For 10% replacement, the result was 29.67, 42.0 and 44.0 N/mm^2 respectively. With 15% replacement, the result was 31, 43.67 and 45N/mm^2 respectively. With 20% replacement, result was 33.33, 35.0 and 46.33 N/mm^2 respectively.

5. Conclusion

From the above results the following points can be concluded:
The Compressive strength of Concrete of grade M20,M25 and M30 increases by replacing the cement with glass powder.

- The compressive strength of Concrete grade M20 increase up to 20% at 7 days and 13% in 56 days where as 11% in 28 days as compared to conventional concrete.
- The compressive strength of Concrete grade M25 increase up to 18% at 7 days and8% at 28 days where as 18% at 56 days as compared to conventional concrete.
- The compressive strength of Concrete grade M30 increase up to 15% at 7 days and 12% in 28 days where as 14% in 56 days as compared to conventional concrete
- The results concluded that there is high initial strength gain in concrete at 7^{th} day.
- It can be concluded that the cement can be replaced up to 20% without any loss in compressive strength of concrete of grades M20, M25 and M30.
- Use of waste glass in concrete can prove to be reasonable as it is a waste material and available in abundance, and help in solving the crisis of disposal of waste glass.

6. Future scope of Research:

- Further study can be carried out using different percentage of waste glass powder and determining the most optimum percentage of glass waste to achieve compressive strength.
- Replacement of cement with glass powder with different water cement ratio.
- In present study OPC of the particular grade was used further different cement can also be tried.
- Tests for other properties of concrete for other concrete grade can be carried out.
- Study on replacing coarse aggregate with glass pieces can be carried out.
- The different type of glass powder can be used.

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