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

[1]Vipan Kumar, [2]Dr. Hemant Sood
[1]PG Student [2]Professor and Head of Civil Engineering Department,
National Institute of Technical Teachers Training and Research, Chandigarh, India.

Abstract:
Tons of waste glass is being produced annually all over the world and this waste is disposed as landfills but as a matter of fact the waste of glass doesn't decompose in the environment. That has created a threat to the environment. So the dissertation work was carried to study the effect of waste glass powder in various concrete grades by partial replacement of cement. Use of milled waste glass in concrete as partial replacement of cement could be an important step toward development of eco-friendly and techno-economical systems. 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 Flexural Strength and Split Tensile Strength at 7th and 28th days and the results were compared with those of conventional concrete.The results show improvement in the Flexural strength and Split Tensile Strength.

Keywords: *Concrete, waste glass powder, Flexural strength, Split Tensile Strength.*

I. INTRODUCTION

Concrete is an all-round composite incorporation of materials consisting of cement, sand, coarse aggregate and water mixed in an appropriate proportion to obtain the desired strength. It has many advantages such as good compressive strength, durability, specific gravity etc. due to which it has proved its efficiency in the vast field of construction industry to build a typical infrastructural applications which include tunnels, large and small buildings, dams and a variety of other major structures in the universe. It has certain disadvantages which include brittleness, low tensile strength, low impact strength, heavy weight etc. These demerits have controlled the civil engineers to direct its ingredients by the addition of a suitable material to have a significant effect in order to develop its mechanical properties. Since long a variety of the materials have been used to avoid its drawbacks such as steel, glass and plastic fibers which have shown the fair results to improve the properties of the concrete.

The amount of glass wastes produced every year is very high.Glass packing industries generate thousand million tons of bottles every year as per studies in India and 0.7% of total urban waste produced is glass waste. The glass is non-biodegradable material and it is not suitable for landfill although glass can be recycled and reused but the cost of recycled glass is more than that of the virgin glass.

Glass is a general product that can be found in different types: bottles, jars, windows ,windshields, bulbs, and cathode ray tubes etc.These goods have a narrow lifetime and generally disposed off after its usage. Utilization of waste glass has fascinated construction industry due to its feasible utilization in concrete. Use of waste glass as aggregate in concrete has been attempted by many scientists.

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 Flexural Strength and Split Tensile Strength at7days and 28 days and was compared with conventional concrete.From the results obtained, it was found that glass powder can be effectively used as cement replacement.

II. 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 Flexural Strength and Split Tensile Strength of concrete when partially replaced by the waste glass powder of size 75µm down The specimens of beams and cylinders were cast by partially replacing cement from 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.

III. EXPERIMENTAL PROCEDURE

A. Materials Used

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

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) 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.

4) Fine Aggregate

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

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.

B. 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 108 numbers of beams of sizes 150x150x500mm and cylinder 108 numbers specimens of size 150x300mm were cast out of which 96 numbers were for partial replacement of cement with waste glass powder and 36 numbers of beams and 36 numbers of cylinder for conventional concrete. The test was carried out for Flexural Strength and Split Tensile strength and compared with conventional concrete of respective grade.

C. 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

D. Testing

1) Flexural Strength Test

The specimen beam of size 150mm x150mm x 500mm were cast and the Flexural Strength test was carried out at 7th and 28th days using Flexural strength testing machine. 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 Flexural strength gain on various percentages of glass powder when tested at 7thand 28th day.

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

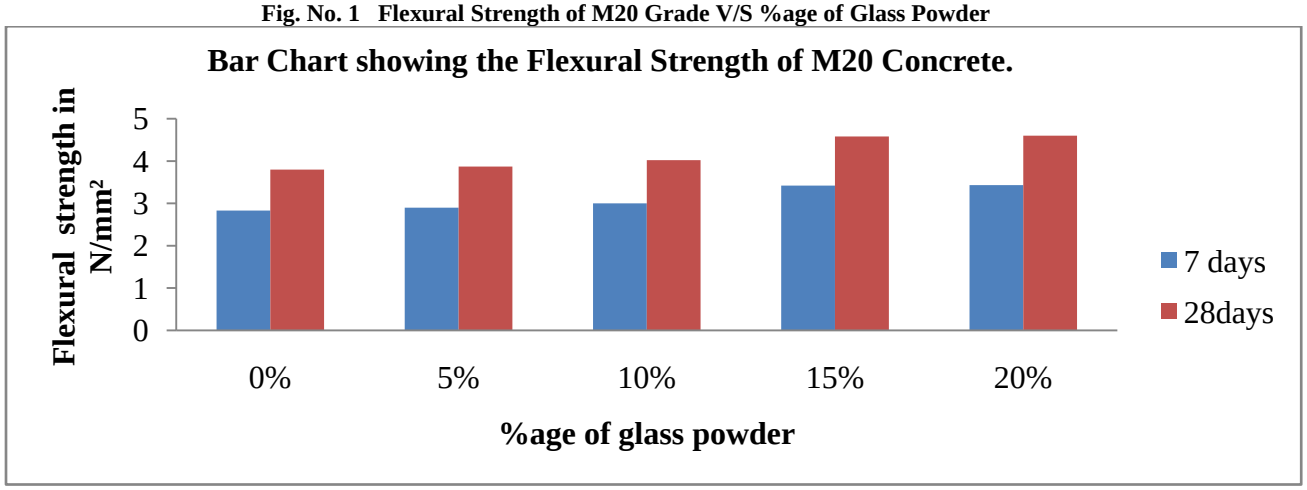

Table No:4

Result of Beam (Grade M20) Flexural Strength in N/mm²				
% of Glass Powder	Flexural strength in N/mm²		Average Flexural strength in N/mm²	
	After 7 days	After 28 days	After 7 days	After 28 days
0%	2.60	3.70	2.83	3.80
	2.50	3.50		
	3.40	4.20		
5%	2.70	3.80	2.90	3.87
	3.60	4.20		
	2.40	3.60		
10%	3.00	3.75	3.00	4.02
	3.20	4.30		
	2.80	4.00		
15%	3.65	4.20	3.42	4.58
	2.90	4.40		
	3.70	5.15		
20%	3.50	5.20	3.43	4.60
	3.90	4.50		
	2.90	4.10		

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

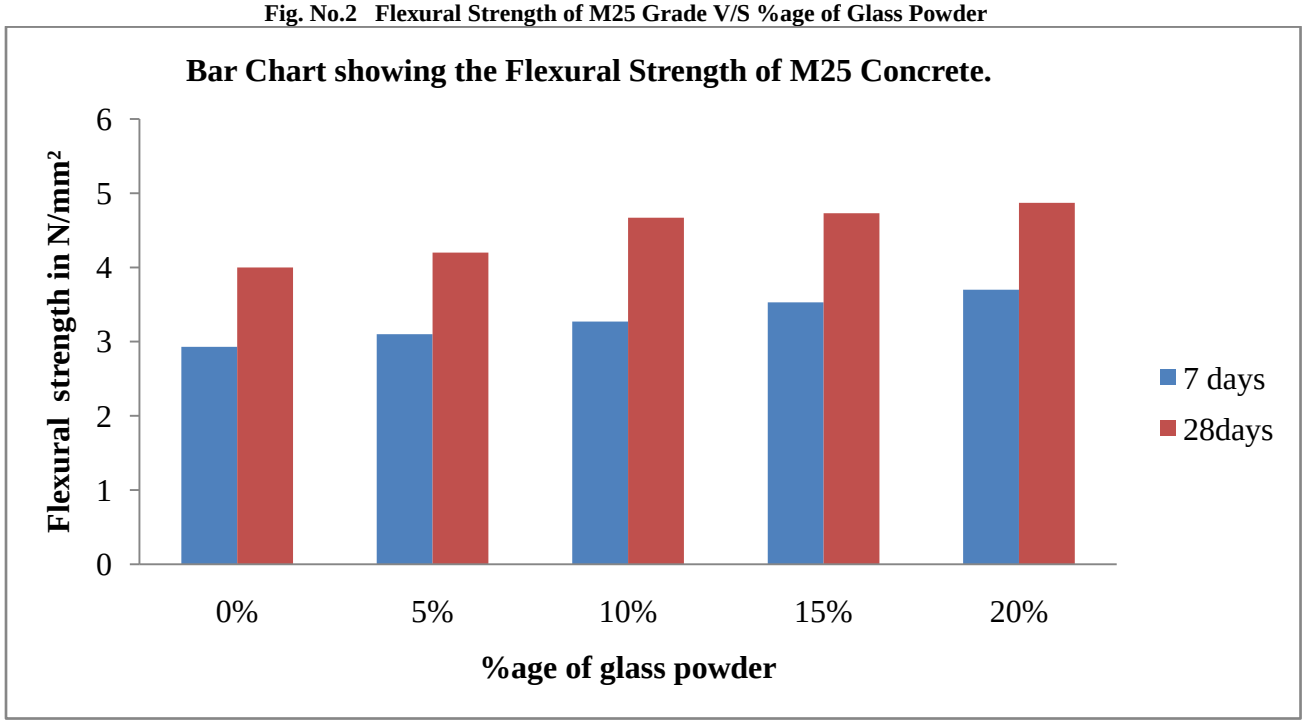

Table No: 5

Result of Beam (Grade M25) Flexural Strength in N/mm²				
% of Glass Powder	Flexural strength in N/mm²		Average Flexural strength in N/mm²	
	After 7 days	After 28 days	After 7 days	After 28 days
0%	3.0	4.0	2.93	4.00
	2.6	3.8		
	3.2	4.2		
5%	3.1	4.6	3.10	4.20
	2.8	3.8		
	3.4	4.2		
10%	3.2	4.8	3.27	4.67
	3.0	4.2		
	3.6	5.0		
15%	3.2	4.8	3.53	4.73
	3.5	5.2		
	3.9	4.2		
20%	3.3	4.8	3.70	4.87
	4.0	5.6		
	3.8	4.2		

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

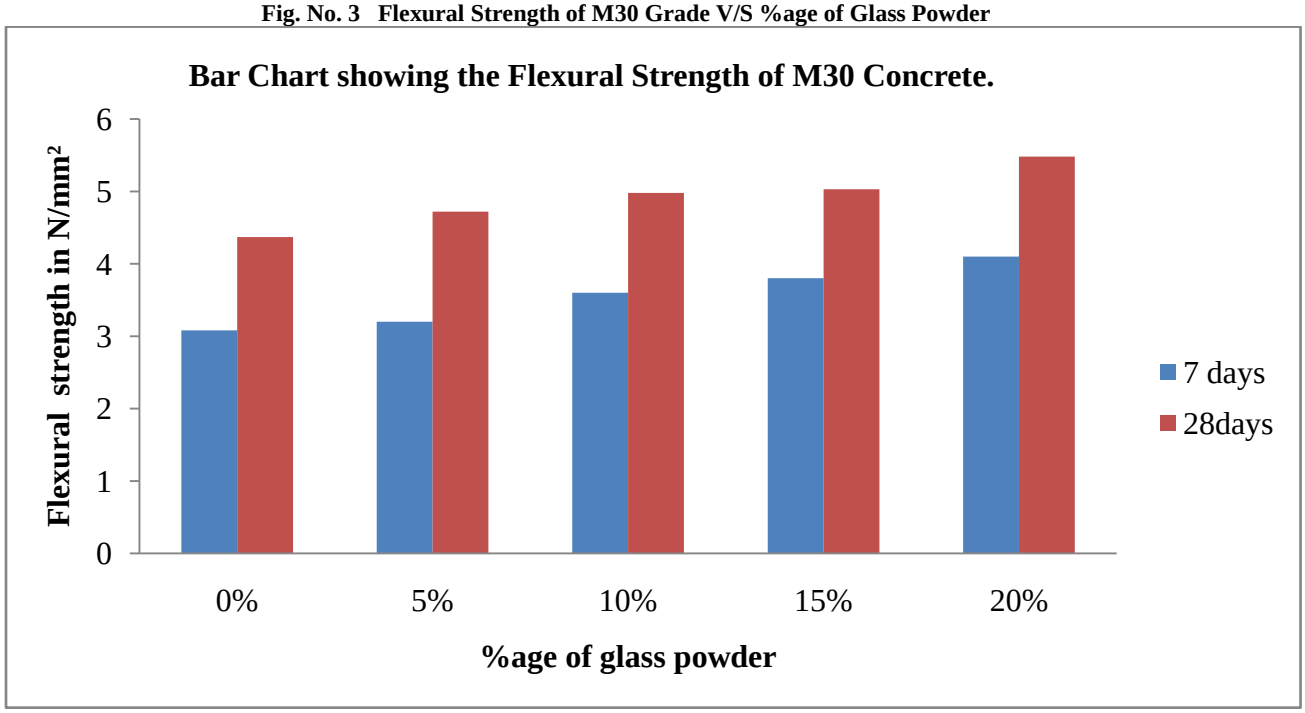

Table No: 6

Result of Beam (Grade M30) Flexural Strength in N/mm²				
% of Glass Powder	Flexural strength in N/mm²		Average Flexural strength in N/mm²	
	After 7 days	After 28 days	After 7 days	After 28 days
0%	2.50	4.70	3.08	4.37
	2.60	3.80		
	4.15	4.60		
5%	3.60	5.30	3.20	4.72
	3.40	4.60		
	2.60	4.25		
10%	3.60	5.45	3.60	4.98
	3.90	4.80		
	3.30	4.70		
15%	4.40	5.10	3.80	5.03
	3.40	5.20		
	3.60	4.80		
20%	3.70	5.20	4.10	5.48
	4.70	5.15		
	3.90	6.10		

2) ***Split Tensile Strength Test***

The specimen Cylinder of size 100mm x200 mm were cast and the Split Tensile Strength test was carried out at 7th and 28th days using Split Tensile strength testing machine. The results obtained are shown in Table No 7, Table No 8 and Table No 9 and Figure No4, Figure No 5 and Figure No 6 show the Flexural strength gain on various percentages of glass powder when tested at 7thand 28th day.

Fig. No. 4 Split Tensile Strength of M20 Grade V/S %age of Glass Powder

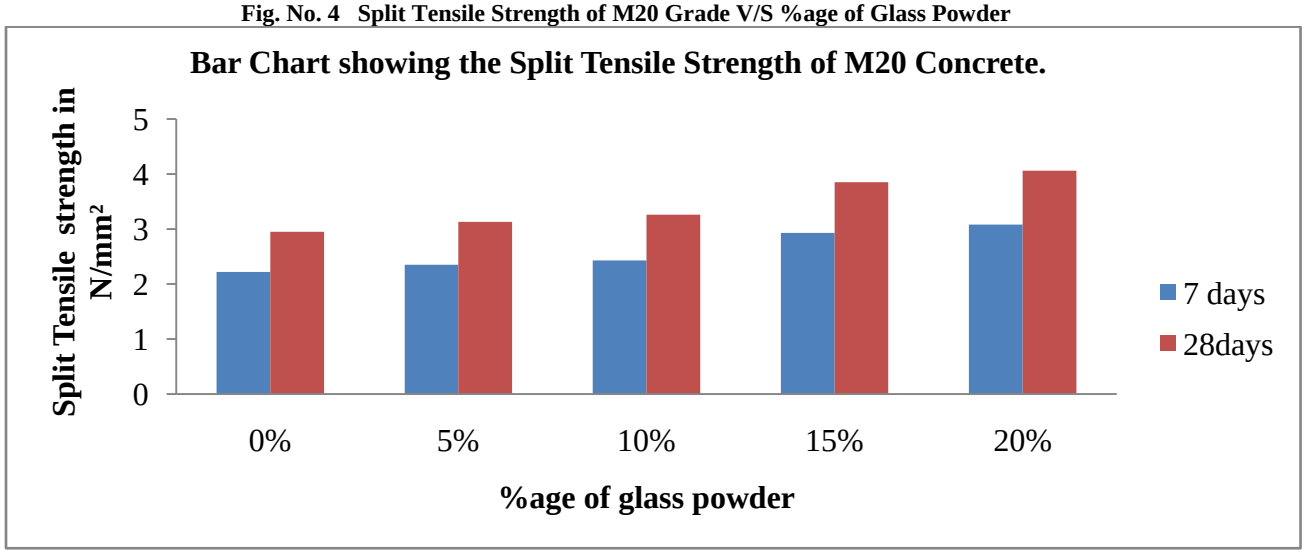

Table No: 7

Result of Cylinder (Grade M20) Split Tensile Strength In N/mm²				
% of Glass Powder	Split Tensile strength in N/mm²		Average Split Tensile strength in N/mm²	
	After 7 days	After 28 days	After 7 days	After 28 days
0%	2.25	2.6	2.22	2.95
	1.9	3.40		
	2.5	2.85		
5%	2.0	2.8	2.35	3.13
	2.4	3.1		
	2.65	3.5		
10%	2.3	3.8	2.43	3.26
	2.85	3.15		
	2.15	2.84		
15%	2.90	4.15	2.93	3.85
	2.7	3.5		
	3.18	3.9		
20%	3.0	4.64	3.08	4.06
	3.45	3.6		
	2.8	3.95		

Fig. No. 5 Split Tensile Strength of M25 Grade V/S %age of Glass Powder

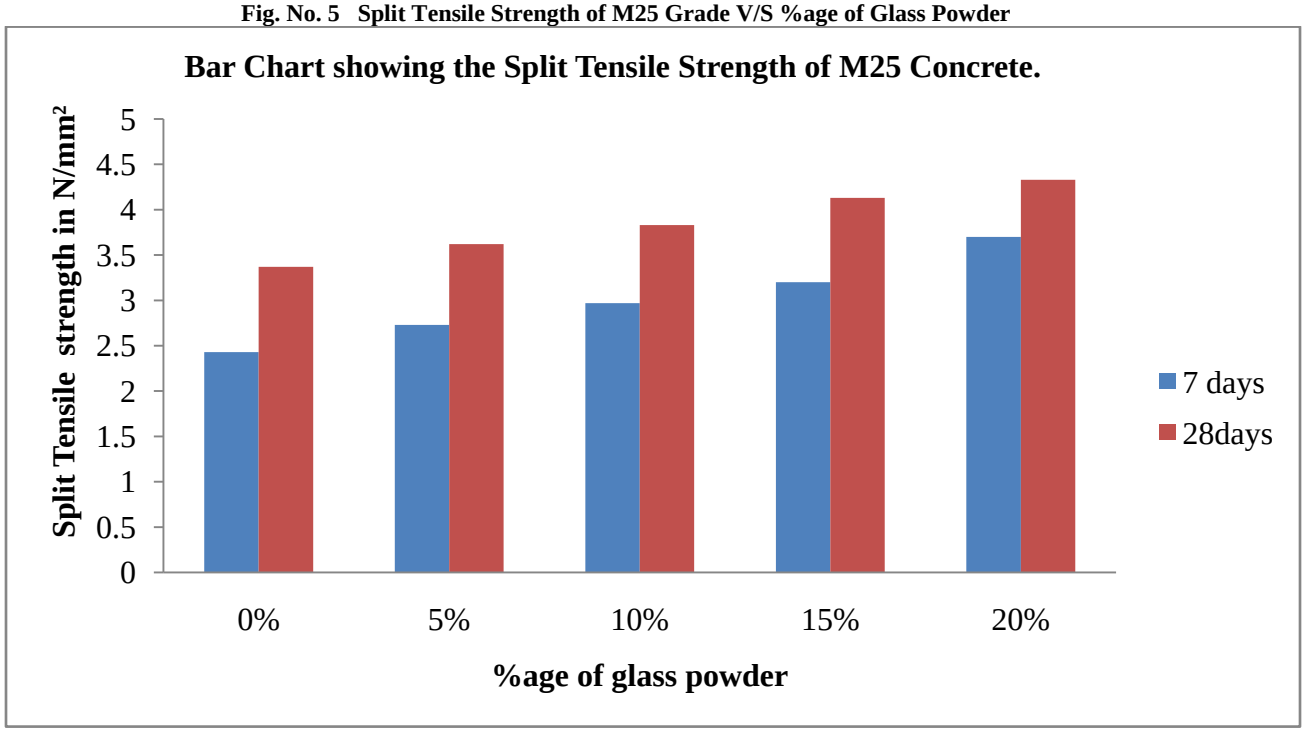

Table No: 8

Result of Cylinder (Grade M25)Split Tensile Strength In N/mm²				
% of Glass Powder	Split Tensile strength in N/mm²		Average Split Tensile strength in N/mm²	
	After 7 days	After 28 days	After 7 days	After 28 days
0%	2.50	3.40	2.43	3.37
	2.00	3.20		
	2.80	3.50		
5%	2.60	3.55	2.73	3.62
	2.50	4.20		
	3.10	3.10		
10%	2.80	4.00	2.97	3.83
	3.10	3.90		
	3.00	3.60		
15%	3.20	4.30	3.20	4.13
	2.80	3.90		
	3.60	4.20		
20%	3.60	4.40	3.70	4.33
	3.50	4.00		
	4.00	4.60		

Fig. No. 6 Split Tensile Strength of M30 Grade V/S %age of Glass Powder

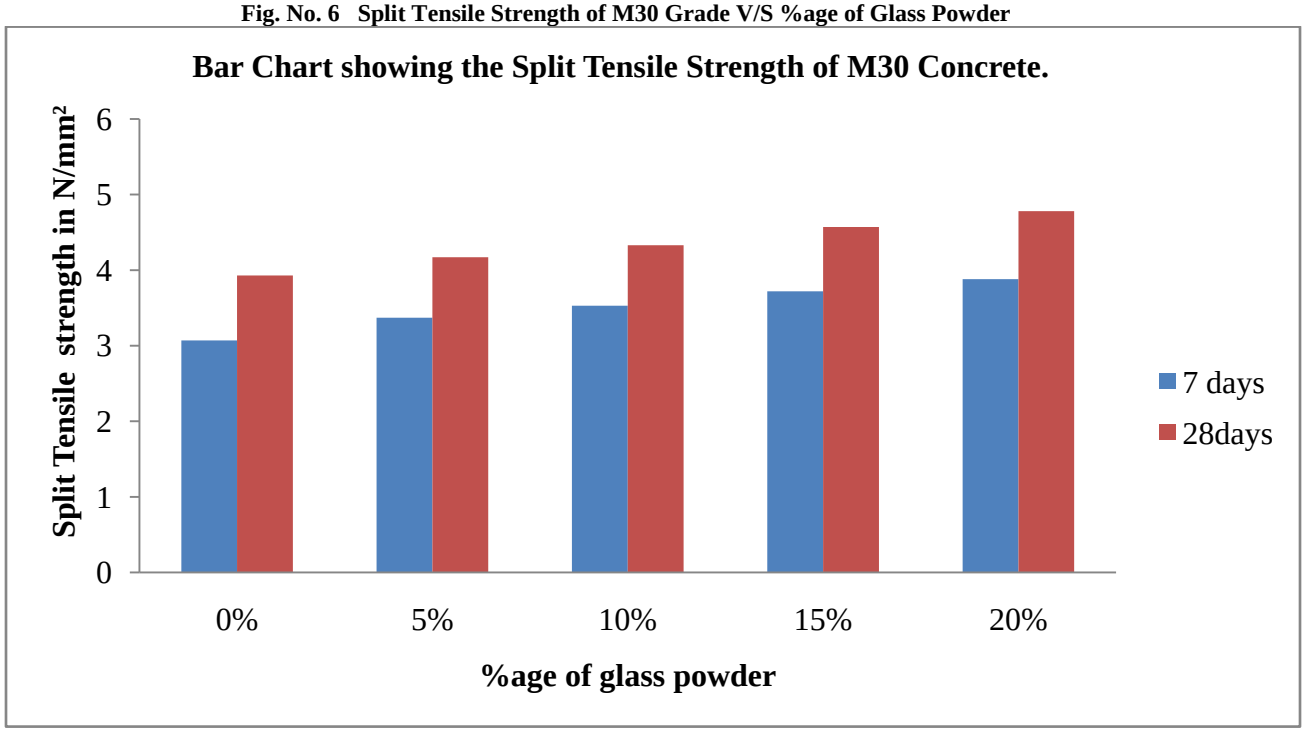

Table No: 9

Result of Cylinder (Grade M30)Split Tensile Strength In N/mm²				
% of Glass Powder	Split Tensile strength in N/mm²		Average Split Tensile strength in N/mm²	
	After 7 days	After 28 days	After 7 days	After 28 days
0%	3.00	4.00	3.07	3.93
	3.40	4.10		
	2.80	3.70		
5%	3.50	4.30	3.37	4.17
	3.40	4.20		
	3.20	4.00		
10%	3.50	4.40	3.53	4.33
	3.70	4.25		
	3.40	4.35		
15%	3.35	4.45	3.72	4.57
	3.70	4.35		
	4.00	4.90		
20%	3.65	4.25	3.88	4.78
	3.80	4.70		
	4.20	5.40		

IV. RESULTS AND DISCUSSION

The effect of glass powder on the Flexural 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 and 28th day was observed.

For conventional concrete of M20 it was 2.83 and 3.80 N/mm^2 respectively. With 5% cement replacement was 2.90 and 3.87 N/mm^2 respectively. With 10% replacement, the result was 3.00 and 4.02N/mm^2 respectively. With 15% replacement, the result was 3.42 and 4.58 N/mm^2 respectively, and by replacing 20% cement result was 3.43 and 4.60 N/mm^2 respectively.

For conventional concrete of M25 it was 2.93 and 4.00 N/mm^2 respectively. The results with 5% replacement were 3.10 and 4.20 N/mm^2 respectively. With 10% replacement, it was 3.27 and 4.67 N/mm^2 respectively. With 15% replacement, it was 3.53 and 4.73 N/mm^2 respectively and for 20% replacement result was 3.70 and 4.87 N/mm^2 respectively.

For conventional concrete of M30 the result was 3.08 and 4.37 N/mm^2 respectively. With 5% replacement, the result was 3.20 and 4.72 N/mm^2 respectively. For 10% replacement, the result was 3.60 and 4.98 N/mm^2 respectively. With 15% replacement, the result was 3.80 and 5.03 N/mm^2 respectively. With 20% replacement, result was 4.10 and 5.48 N/mm^2 respectively.

The effect of glass powder on the Split Tensile of concrete also 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 and 28th day was observed.

For conventional concrete of M20 it was 2.22 and 2.95 N/mm^2 respectively. With 5% cement replacement was 2.35 and 3.13 N/mm^2 respectively. With 10% replacement, the result was 2.43 and 3.26 N/mm^2 respectively. With 15% replacement, the result was 2.93 and 3.85 N/mm^2 respectively, and by replacing 20% cement result was 3.08 and 4.06 N/mm^2 respectively.

For conventional concrete of M25 it was 2.43 and 3.37 N/mm^2 respectively. The results with 5% replacement were 2.73 and 3.62 N/mm^2 respectively. With 10% replacement, it was 2.97 and 3.83 N/mm^2 respectively. With 15% replacement, it was 3.20 and 4.13 N/mm^2 respectively and for 20% replacement result was 3.70 and 4.23 N/mm^2 respectively.

For conventional concrete of M30 the result was 3.07 and 3.90 N/mm^2 respectively. With 5% replacement, the result was 3.23 and 4.32 N/mm^2 respectively. For 10% replacement, the result was 3.37 and 4.56 N/mm^2 respectively. With 15% replacement, the result was 3.42 and 4.58 N/mm^2 respectively. With 20% replacement, result was 3.50 and 4.67 N/mm^2 respectively.

V. CONCLUSION

From the above results the following points can be concluded:

The Flexural strength and Split Tensile Strength of Concrete of grade M20, M25 and M30 increases by replacing the cement with glass powder.

- The Flexural Strength of Concrete grade M20 increase up to 21% at 7 days and 28 days as compared to conventional concrete.
- The Flexural strength of Concrete grade M25 increase up to 27 % at 7 days and 22% at 28 days as compared to conventional concrete.
- The Flexural strength of Concrete grade M30 increase up to 33% at 7 days and 26% in 28 days as compared to conventional concrete.
- The Split Tensile Strength of Concrete grade M20 increase 39% at 7 days and 38% at 28 day as compared to conventional concrete.
- The Split Tensile Strength of Concrete grade M25 increase 40% at 7 days and 28% at 28 day as compared to conventional concrete.
- The Split Tensile Strength of Concrete grade M30 increase 26% at 7 days and 22% at 28 day as compared to conventional concrete.
- The results concluded that there is high initial strength gain in concrete at 7th day.
- It can be concluded that the cement can be replaced up to 20% without any loss in Flexural Strength and Split Tensile 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 and available in abundance, and help in solving the crisis of disposal of waste glass.

VI. FUTURE SCOPE OF RESEARCH

- Further study can be carried out using different percentage of using waste glass powder and determining the most optimum percentage of glass waste to achieve Flexural strength and Split Tensile 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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