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Waste Glass Powder as a Partial Replacement of PPC

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Abstract: ***Concrete is the mixture of various materials 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 increase the threat of sustainable concrete. Around 7% of greenhouse gases are emitted by cement industry in the earth's atmosphere. Today various researchers are studying the use of supplementary material which posses cementitiuos properties for example fly ash, silica fumes, blast furnace slag etc. Just like other waste products like fly ash, silica fume etc. glass powder is also used as a partial replacement of cement. Waste glass in the form of fine aggregate or as alternative cement can be used. Researchers has investigated that glass posses a pozzolana properties due to increase in silica content, so it can be replace cement to some degree and can improve the strength and also increase the durability of concrete. In this study the glass powder replaces the Portland pozzolana cement from 0% to 25%, at interval of 5% and the various properties of concrete is tested. At 3rd, 7th and 28th day the compressive strength is measured while the flexural strength is measured at 28th day. In addition to this the slump value, the water absorption and the cube density were also measured and all the properties were compared with the conventional concrete. The results concluded that the waste glass powder can be used as a partial replacement of cement.***

Keywords: Pozzolana Portland cement, waste glass powder, compressive strength, density, water absorption

1. Introduction

The cement industry is facing various problems like reduce the emission co2, increase cost energy supply and requirement of natural non-renewable raw materials so attempts has been made to use recycle glass powder in Portland cement and concrete. The uses of waste glass in place of cement will reduce the usage of cement the emission of c o_2 and other greenhouse gases; emitted in the manufacturing of cement.

Glass is an amorphous material with high silica content(SiO_2) i.e.72%wate glass when grounded to very fine powder (600 micron) reacts with alkali in cement (Pozzolana reaction) &cementations product that help to contribute to the strength development **[VeenaV. Bhat, N.Bhavanishankar Rao,2014]**.when glass powder is added as a pozzolana ,it provides a large volume of hydration products & uniform distribution. The added glass provider in concrete changes the cement paste structure. The resulting paste contains more of the strong calcium silicate hydrate(C-S-H) & less of the weak & easily hydroxides $[CaOH)_2$ than ordinary cement paste **[R. Vadhiyan et al ,2013] .** The micro filler effect of glass powder will reduce the permeability of concrete and impact the better paste to aggregate bond of concrete as compared to normal conventional concrete

2. Objectives of the Investigation

Experiments were conducted to evaluate the effect on concrete, when cement is partially replaced by waste glass powder which is generated by various glass industries and waste generated by broken glass doors and windows.

The main objective of this research is to assess the properties of concrete when partially replaced by the waste glass powder of size 90µm. The specimens of cube and beam were casted by partially replacing cement from waste glass powder by 5%, 10%, 15%, 20%, 25% for two different grades of concrete i.e. M20 and M 30. The results obtained from various test were compared with conventional concrete. So the objectives of the thesis are as follows:

a) Partial replacement for the Portland Pozzolana cement to make the cement more economical and aims at sustainable development of concrete
b) The optimum percentage of glass powder at which the maximum strength can be achieved as compared to conventional concrete
c) To evaluate the effect on structural properties of concrete.

3. Experimental Procedure

3.1 Material used

3.1.1 Cement

The PPC confirming to IS 1489.1.1991 of Jaypee group is used in this research and has the following physical properties in Table 1.

Table 1: Physical Properties

Properties	*Results*
Specific Gravity	2.85
Normal Consistency	33%
Compressive strength at 7th day	24.03
Final Setting time	240
Initial Setting time	190
Fineness Modulus	3.75%

3.1.2 Glass Powder

Physical properties of waste glass powder obtained from discarded glass products is tabulated in Table 2

Table 2: Physical Properties

Properties	*Results*
Specific Gravity	2.60
Fineness passing 90µm	98
Colour	White

3.1.3 Fine Aggregate

The locally available sand confirming to zone II having the specific gravity 2.48 was used. The test performed was done as per Indian Standard Specifications IS: 383-1970. The results of sieve analysis have been tabulated in Table 3.

Table 3: Sieve Analysis

Is Sieve	*Weight Retained In (gm)*	*% Weight Retained*	*Cumulative % Weight Retained*	*Cumulative % Passing*	*Std. Requirement for zone II (IS 383 : 1970)*
4.75mm	6	0.6	0.6	99.4	90-100
2.36mm	33	3.3	3.9	96.1	75-100
1.18mm	122	12.2	16.1	83.9	55-90
600µm	300	30	46.1	53.9	35-59
300µm	460	46	92.1	7.9	8-30
150µm	51	5.1	97.2	2.8	0-10
PAN	28	2.8	100	-	-

3.1.4 Coarse Aggregate

The coarse aggregate for this research is 20mm down size with specific gravity 2.8. The tests are carried out as per IS 2386. The results of sieve analysis are shown in Table 4.

Table 4: Sieve Analysis

Is Sieve	*Weight Retained In (gm)*	*% Weight Retained*	*Cumulative % Weight Retained*	*Cumulative % Passing*
20mm	739	14.78	14.78	85.22
16mm	2423	48.48	63.24	36.66
12.5mm	996	19.92	83.16	16.84
10mm	773	15.46	98.62	1.38
4.75mm	50	1	99.62	0.38
PAN	-	-	-	-

3.2 Experimental plan

In this investigation, the PPC is replaced by waste glass powder by 5%, 10%, 15%, 20%, 25% for M20 and M30 grade concrete. Cube specimens of size 150mm x 150mmx 150mm of 57 numbers and 12 beams of size 100mmx 100mm x 500mm for each grade of cement were casted with partial replacement of cement by waste glass powder. The test was carried out for different properties of concrete unit weight, compressive strength, tensile strength and water absorption as per IS: 516 – 1959.

3.3 Mix design

As per IS 456:2000 and IS 10262:2009 the mix design for M20 and M30 grade concrete was made. The materials as per design are given in Table5.

Table 5: Material Required

Grade of Concrete	*w/c ratio*	*Quantity Of Material (kg/m^3)*		
		cement	*Fine aggregate*	*Coarse aggregate*
M 20	0.5	384	634	1170
M 30	0.4	480	603	1111

3.4 Testing

3.4.1 Unit weight of concrete

The test was conducted to study the variation of unit weight of cube for each grade of concrete. The results have been tabulated in Table 6.

Table 6: Unit Weight of the Concrete

% Glass powder	*M 20 Grade*		*M 30 Grade*	
	Wt. of cube (kg)	*Unit weight of cube (kg/m^3)*	*Wt. of cube (kg)*	*Unit weight of cube (kg/m^3)*
0	8.606	2549	8.725	2585
5	8.511	2521	8.295	2457
10	8.433	2498	8.060	2388
15	8.300	2459	8.015	2374
20	8.120	2405	7.975	2362
25	7.950	2355	7.850	2325

The variation in unit weight of concrete when cement is partially replaced by water is shown in Figure 1.

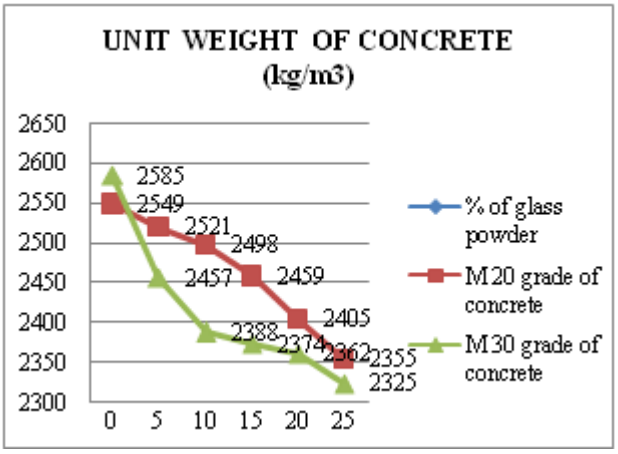

Figure 1: Unit Weight of Concrete Cube V/S Percentage of Glass Powder

3.4.2 Compression strength test

The specimen cubes of size 150mm x 150mmx 150mm were casted and the compressive strength test was carried out as per IS: 516 – 1959 at 3rd, 7th and 28th days using compression testing machine. The results obtained from the test have been tabulated in Table 7.

Table 7: Compressive Strength of Concrete

% of Glass Powder	*Compressive strength of concrete (MPa)*					
	M 20 Grade concrete			*M 30 Grade Concrete*		
	3rd day	*7th day*	*28th day*	*3rd day*	*7th day*	*28th day*
0	10.64	19.55	27.11	14.67	25.77	36
5	11.55	22.22	29.33	16.88	27.55	37.75
10	15.55	24.88	35.11	22.22	30.23	41.31
15	14.22	22.67	32.44	21.33	28.88	38.68
20	12.44	20.88	28.88	14.67	26.22	36.42
25	9.33	18.22	26.22	13.33	24.44	35.13

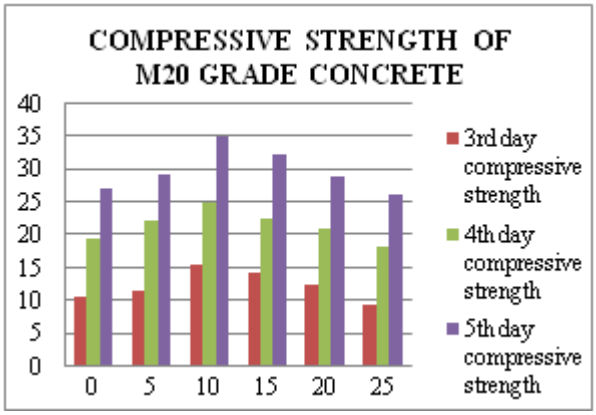

Figure 2: Compressive Strength of M20 Grade V/S %Of Glass Powder

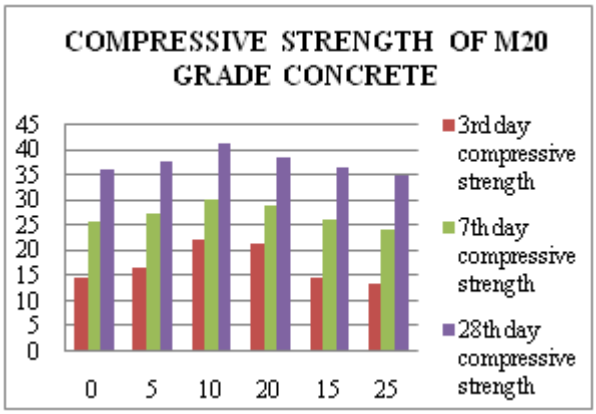

Figure 3: Compressive Strength of M30 Grade V/S % of Glass Powder

3.4.3 Flexural strength test

The beam specimens of 10mm x 10mm x 150mm were casted for flexural strength test of each grade. The test was conducted as per IS: 516 – 1959 at 28th day with flexural testing machine. The flexural strength of concrete changes as the percentage of waste glass powder varies. The results have been tabulated in Table 8.

Table 8: Flexural Strength Of Concrete (Mpa) At 28th Day

% of Glass Powder	*Flexural Strength Of Concrete (Mpa) At 28th Day*	
	M 20 Grade concrete	*M 30 Grade concrete*
0	3.33	4.11
5	3.68	4.24
10	4.08	4.82
15	3.75	4.29
20	3.49	3.92
25	3.32	3.85

The variations on flexural strength of M20 and M30 grade concrete have been shown in Figure4.

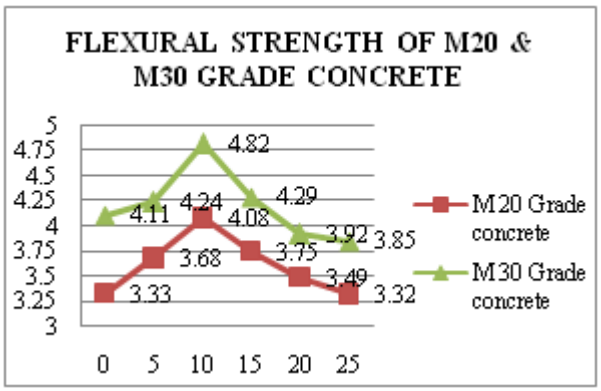

Figure 4: Flexural Strength of Concrete V/S % of Glass Powder

3.4.4 Water absorption test

The water absorption test was carried out to study the variation in the water absorption capacity of concrete. The specimen cubes were casted of size 150mmx 150mm x 150mm for each grade of concrete, M20 and M30. The results of M20 & M30 grade concrete has tabulated in Table 9 and Table 10.

Table 9: Water Absorption Capacity of M 20 Concrete

% of GLP	*Average Wet Weight (kg)*	*Average Dry Weight (kg)*	*Water Absorbed (kg)*	*Water Absorption (%)*
0	8.595	8.490	0.105	1.23
5	8.500	8.405	0.95	1.13
10	8.400	8.321	0.79	0.94
15	8.283	8.216	0.67	0.81
20	8.090	8.030	0.60	0.74
25	7.993	7.950	0.43	0.54

Table 10: Water Absorption Capacity of M 30 Concrete

% of GLP	*Average Wet Weight (kg)*	*Average Dry Weight (kg)*	*Water Absorbed (kg)*	*Water Absorption (%)*
0	8.815	8.705	0.110	1.26
5	8.330	8.250	0.80	0.96
10	8.130	8.055	0.75	0.93
15	8.000	7.940	0.60	0.75
20	7.990	7.935	0.55	0.69
25	7.890	7.840	0.50	0.63

The variation in the water absorption capacity of concrete has been shown in Figure 5.

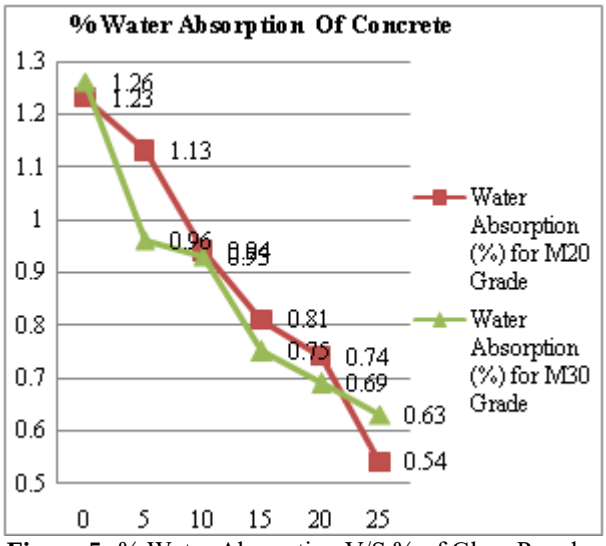

Figure 5: % Water Absorption V/S % of Glass Powder

4. Result and Conclusion

The effect of glass powder on the properties of cement has been studied in this research. The various properties of concrete such as compressive strength, unit weight, flexural strength and the percentage water absorption are studied. The tests are performed for two grade of concrete, M20 and M30.

As the percentage of waste glass powder is increased in the concrete, the unit weight of concrete decreases for both grades of concrete. The unit weight of concrete decreases with increase in percentage of waste glass powder in concrete. The unit weight for M 20 grade concrete ranges from 2549 – 2355 for waste glass powder percentage from 0% - 25%. The unit weight for M 30 grade concrete ranges from 2585 – 2325 for waste glass powder percentage from 0% - 25%. There was an appreciable increment in the compressive strength of concrete when the percentage of glass powder was increased upto 10% at 3^{rd}, 7^{th} and 28^{th} day for M 20 and M 30 grade of concrete.. The compressive strength at 10 % waste glass powder at 3^{rd} day was 15.55 MPa at 7^{th} day it was 24.88 MPa and at 28^{th} day it was 35.11MPa. Similarly the flexural strength of concrete increases upto 10% waste glass powder. For M 20 grade of concrete the flexural strength is 4.08 MPa while that of M 30 is 4.82 MPa. The percentage water absorption decreased upto 0.54% at 25% of waste glass powder for M 20 and for M 30 it is 0.63%.

From the above results the following point are concluded:-

- For M 20 Grade concrete there was 7.62 % decrement in the unit weight of concrete while there was 10.02 % decrement in the unit weight of concrete for M 30 when compared to unit weight of conventional concrete
- The increment of 46%, 27% and 29% in compressive strength at 3^{rd}, 7^{th} and 28^{th} day of M 20 grade concrete was observed as compared to conventional concrete
- The compressive strength of M 30 grade concrete also showed an increment of 51.46%, 17.33 % and 14.8% at 3^{rd}, 7^{th} and 28^{th} day as compared to conventional concrete
- For M 20 grade concrete there was 22.5% increment in the flexural strength of concrete while there was 17% increment for M 30 grade when compared to conventional concrete.
- The percentage water absorption was decreased as compared to conventional concrete.
- Optimum replacement percentage for waste glass powder is found to be 10% at which the strength of concrete increases.
- The results also concluded that there is high early strength gain in concrete at 3^{rd} day while at 7^{th} and 28^{th} day there was a considerable increment in the compressive strength of concrete.

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