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To study the concrete with partial replacement of cement by glass powder

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Abstract: *The production of various materials fundamentally uses raw materials, which leads to depletion of raw material sources and rises the cost of it. As there is growing environmental awareness in the community, scientists and technologists have to notice and think over to invent various techniques and methodologies to recover, reuse and recycle the waste products. Glass powder is such a waste product. Since it contains silica as its main constituent which makes it potentially pozzolanic material. Keeping this view in mind, many of the researchers have conducted studies on this type of experiment; where a part of cement was replaced by glass powder in concrete and the results were published, which gave mixed opinions. But a large part of the researchers are successful enough in finding the maximum compressive strength of concrete at 20% replacement with intervals such as 5% and 10%; this has created a gap in the data; which don't allow to get the wide range of data and effective use of glass powder further. Getting an idea to fill this gap, in this particular experiment, the glass powder is replaced around 20% replacement from 18% to 22% with the interval of 1% as the partial replacement of cement in the concrete; to get the compressive strength against conventional concrete. This can be useful to understand the strength development, effective use and to get the wide range of data regarding the use of glass powder in concrete.*

Key Words: *Glass Powder Concrete (GPC), Cement, Glass Powder (GP), Concrete, Partial Replacement, Fine Aggregate (FA), Coarse Aggregate (CA), Conventional Concrete (CC)*

1. INTRODUCTION:

Nature has made provision of natural resources and raw materials on earth in excess for their fair use, although nothing is unlimited. As mentioned in the abstract about raw materials, the recover, reuse and recycle policy must be followed for the waste products to save raw materials and also to use renewable and other forms of energy resources. Glass powder is such a waste product, which can be effectively used in concrete as partial replacement of cement in strength building. Glass contains silica as its major component which shows its pozzolanic behaviour. Silica (Silicon dioxide - SiO_2) is the second largest component of cement ingredients which is about 17 to 25% (Mayur Bagde). Concrete is the most important material used in the construction industry. Therefore by using glass powder in concrete the consumption of cement can be reduced so that the environmental pollution can be checked. Also the volume of waste glass sent to landfills can be reduced. As useful recycled material, glass powder can be used in civil engineering domain, for example, in cement, as supplementary cementitious materials. Its recycling ratio is close to 100%, and can be used in concrete without adverse effects in concrete durability. Hence, it is believed to be an ideal replacement material.

Keeping this view in mind, many of the researchers have conducted studies on this type of experiment already; where a part of cement was replaced by glass powder and the results were published, which gave mixed opinions. Some of them got the results at 10% replacement while others at 20%. But a large part of the researchers are successful enough in finding the maximum compressive strength of concrete at 20% replacement with intervals such as 5% and 10%; this has created a gap in the data; which don't allow to get the wide range of data and effective use of glass powder further. Getting an idea to fill this gap, in this particular experiment, the glass powder is replaced around 20% replacement from 18% to 22% with the interval of 1% as the partial replacement of cement in the concrete; to get the compressive strength against conventional concrete. This can be useful to understand the strength development, effective use and to get the wide range of data regarding the use of glass powder in concrete.

2. MATERIALS:

With an aim to check the compressive strength of concrete with partial replacement of cement by glass powder, essentially needs the concrete. So to make a concrete block, the need is cement, fine aggregate, coarse aggregate and water. And as the title suggest, the ingredient of most importance here is glass powder. All these materials are required to be in proportion so as to make a proper paste to get a proper concrete; which are then casted in the blocks, so as to get the results of compressive strength.

Cement: A locally available cement is used; which is Ordinary Portland cement of 43 grade is conforming to IS 8112. Cement is tested for field testing followed by lab testing. Properties are tabulated in Table III.

Glass Powder: Locally available broken waste glass is used and it is then crushed into the Los Angles Abrasion Test Machine to get a powder form of it. It is then passed through 90µm sieve. Glass powder of particle size 90 µm and below is used in this experiment. Properties are tabulated in Table IV.

Fine Aggregate and Coarse Aggregate: Natural sand is used in the range 4.75mm to 150 micron size. Also coarse aggregate of size from 20mm to 4.75mm is used. Properties are tabulated in Table V. Also the sieve analysis for FA conforming to IS 383 – 1973 (page no. 11, table 4) is shown in Chart I.

Water: Potable water is used.

3. METHOD:

In this experiment, a total of six types of concrete mixes are prepared. First type is conventional cement concrete. Remaining are glass powder concrete (GPC) where the cement is partially replaced by glass powder from 18% to 19% with the interval of 1% i.e. 18%, 19%, 20%, 21% and 22%. For this purpose, a concrete mix of M30 grade of concrete is used. The mix design is carried out for M30 grade of concrete by IS 10262 : 2009; resulted mix proportion as shown in Table IV:

Table I: Mix Design per Cubic Meter of Cement

Sr. No.	Particulars	Water (Kg/m^3)	Cement (Kg/m^3)	FA (Kg/m^3)	CA (Kg/m^3)
1	As per Mix Design	191.6	425.78	549.63	1212.67
2	For 1Kg Cement	0.45	1	1.29	2.84
3	For 50Kg Cement	22.5	50	64.5	142

To carry out the compressive strength of respective concrete; a total of 54 nos. of test specimens of dimensions 150mm×150mm×150mm are required. Accordingly the test specimens were prepared with the mix proportion. To check the workability of concrete, slump cone test on the fresh concrete is done. The slump cone value test findings for the slump cones is shown in Chart II. The concrete blocks were then kept for curing purpose. At last the blocks were tested under compressive testing machine (CTM) after finishing the curing period of 7 days, 14 days and 28 days to know the compressive strength of the respective types of concrete. The compressive strength for the conventional concrete and GPCs for 7 days, 14 days and 28 days of curing period is shown in Chart III, IV and V respectively.

Table II: Details of Test Specimens

Sr. No.	Type of Mix	7 Days	14 Days	28 Days
1	Conventional Concrete	3	3	3
2	18% GPC	3	3	3
3	19% GPC	3	3	3
4	20% GPC	3	3	3
5	21% GPC	3	3	3
6	22% GPC	3	3	3
	SUBTOTAL	18	18	18
	TOTAL	**54**		

4. FINDINGS :

Properties of materials used in this experimental studies are tabulated as shown below:

Table III: Properties of Cement

Sr. No.	Properties	Results
1	Fineness Modulus	2%
2	Standard Consistency	32%
3	Initial Setting Time	33 minutes
4	Specific Gravity	3.1

Table IV: Properties of Glass Powder

Sr. No.	Properties	Results
1	Colour	Greyish White
2	Fineness Passing 90µm	98.5

Table V: Properties of FA and CA

Sr. No.	Properties	Fine Aggregate	Coarse Aggregate
1	Type	River Sand	Crushed Angular
2	Specific Gravity	2.34	2.78
3	Fineness Modulus	2.2 (Zone III)	----
4	Water Absorption	----	1.05%

Chart I: Sieve Analysis of FA

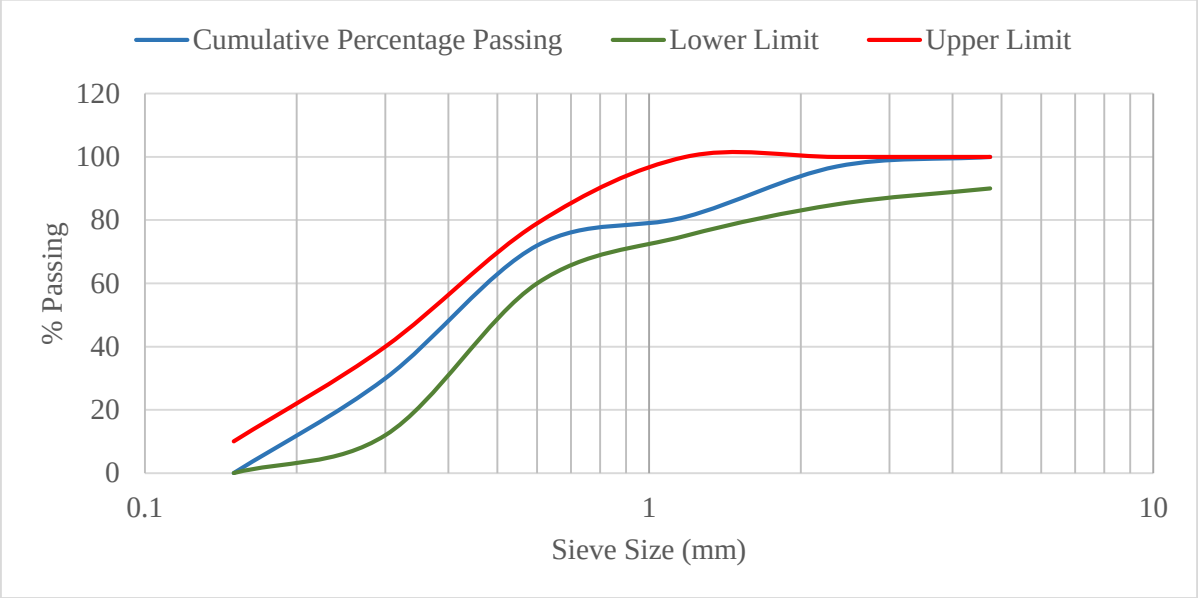
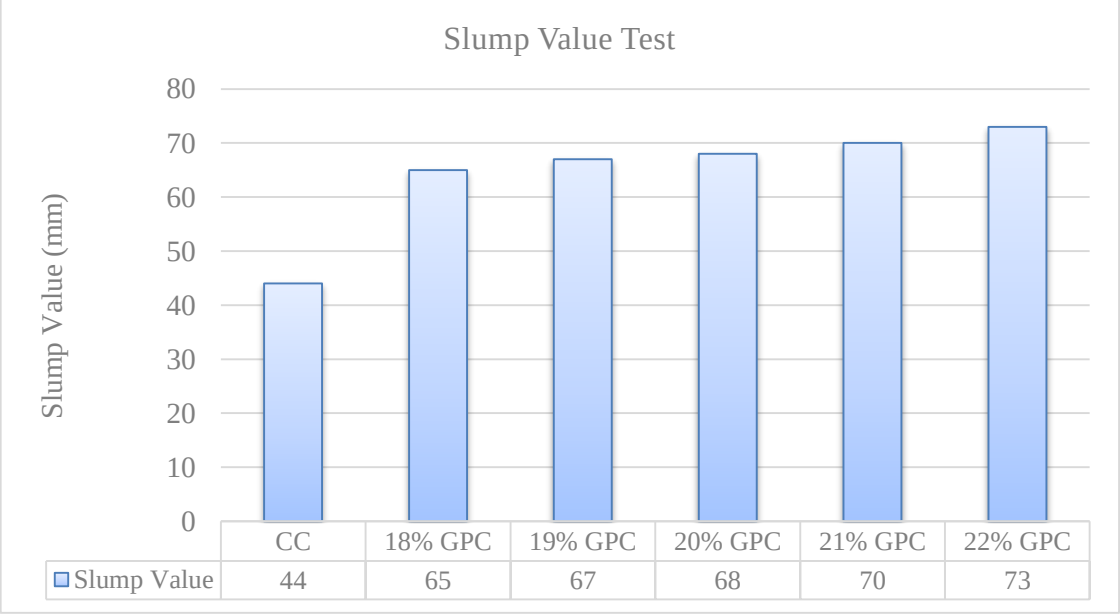
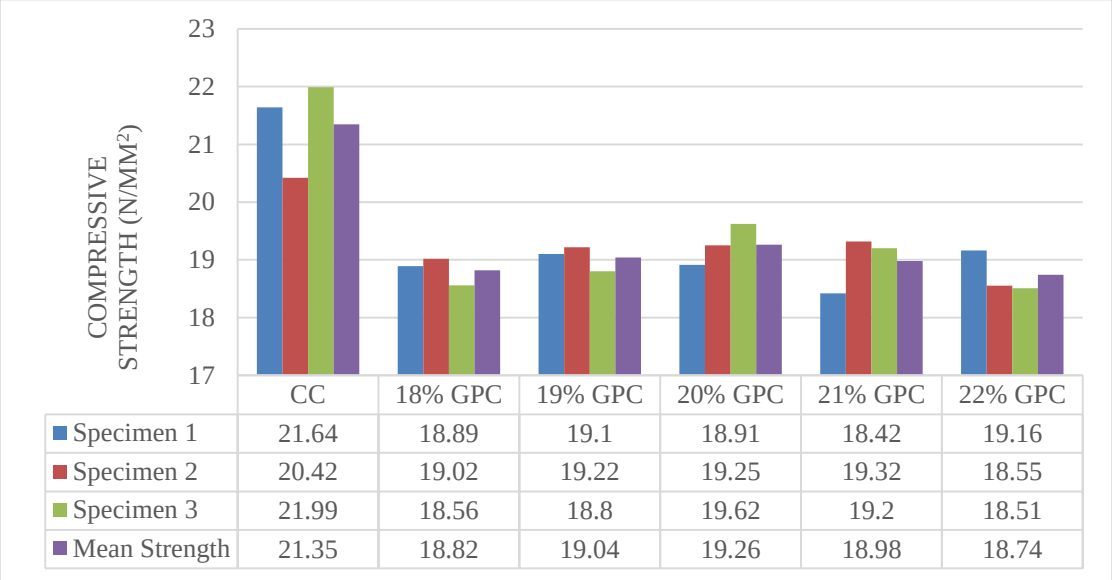


Chart II: Slump Cone Value Test



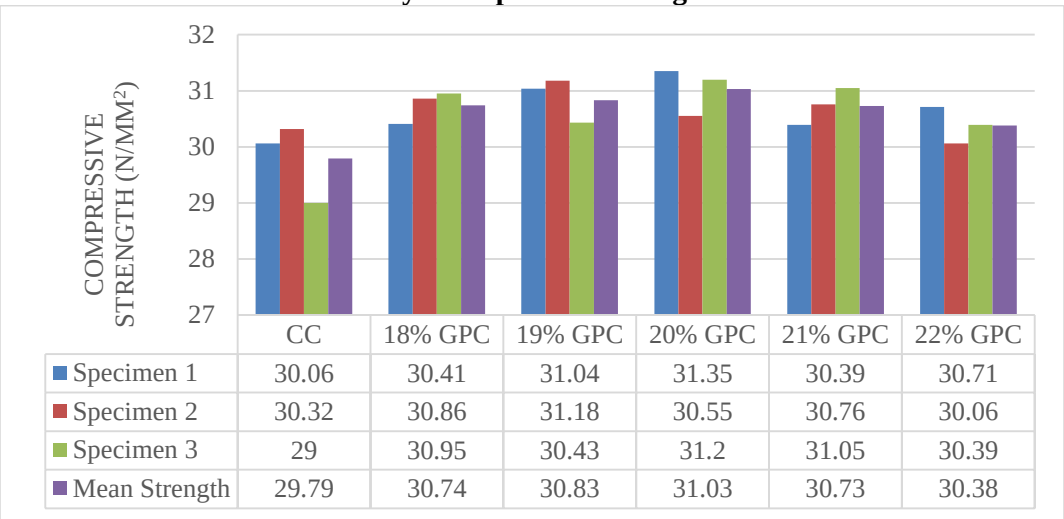
The findings from compressive strength test after finishing the curing period of 7 days, 14 days and 28 days on the test specimens of size 150mm×150mm×150mm is shown below:

Chart III: 7 Days Compressive Strength of Concrete



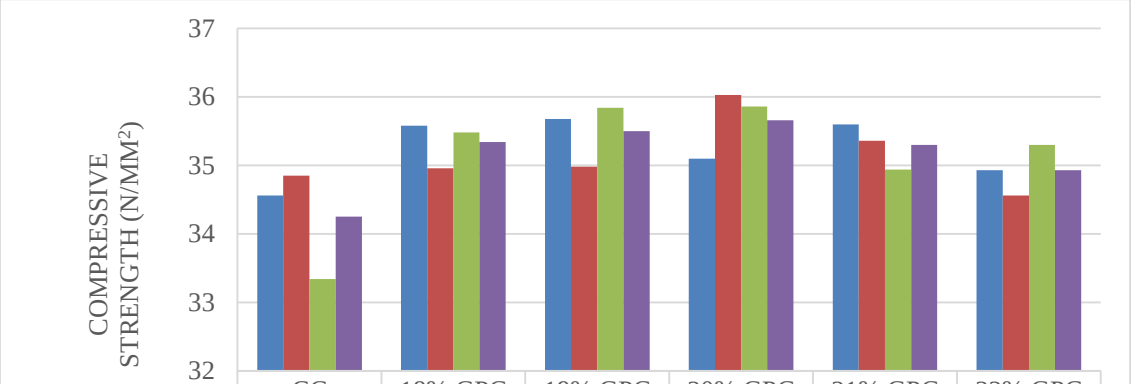
	CC	18% GPC	19% GPC	20% GPC	21% GPC	22% GPC
Specimen 1	21.64	18.89	19.1	18.91	18.42	19.16
Specimen 2	20.42	19.02	19.22	19.25	19.32	18.55
Specimen 3	21.99	18.56	18.8	19.62	19.2	18.51
Mean Strength	21.35	18.82	19.04	19.26	18.98	18.74

Chart IV: 14 Days Compressive Strength of Concrete



	CC	18% GPC	19% GPC	20% GPC	21% GPC	22% GPC
Specimen 1	30.06	30.41	31.04	31.35	30.39	30.71
Specimen 2	30.32	30.86	31.18	30.55	30.76	30.06
Specimen 3	29	30.95	30.43	31.2	31.05	30.39
Mean Strength	29.79	30.74	30.83	31.03	30.73	30.38

Chart V: 28 Days Compressive Strength of Concrete

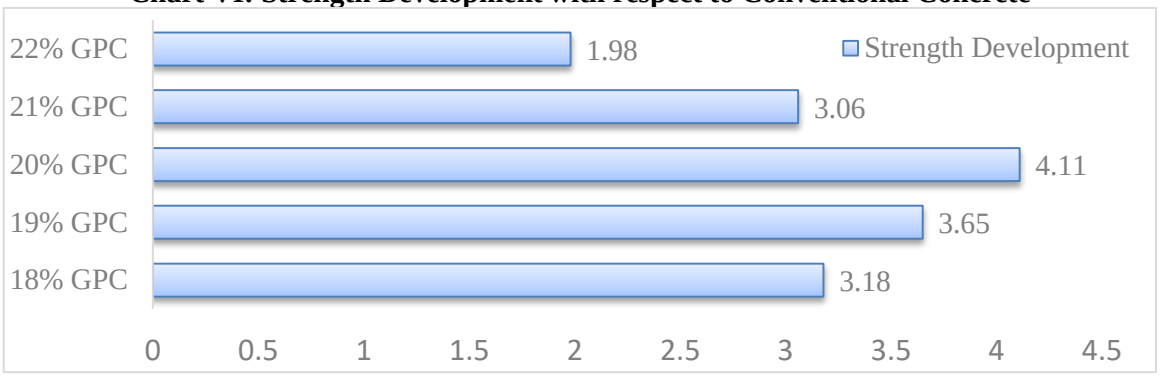


	CC	18% GPC	19% GPC	20% GPC	21% GPC	22% GPC
Specimen 1	34.56	35.58	35.68	35.1	35.6	34.93
Specimen 2	34.85	34.96	34.98	36.03	35.36	34.56
Specimen 3	33.34	35.48	35.84	35.86	34.94	35.3
Mean Strength	34.25	35.34	35.5	35.66	35.3	34.93

5. RESULT:

Initially after 7 days of curing period the strength of conventional concrete seems to be higher. But as the days pass on at 14 days of curing period the strength building process of GPCs progresses. An finally, at 28 days curing period the strength building is at highest which shows the 20% GPC have the highest of compressive strength. Strength Development with respect to Conventional Concrete: It can be clearly seen from the findings of this experimental study, the maximum strength is developed at 20% GPC followed by 19% GPC. The replacement of 20% cement with glass powder resulted into maximum strength development of 4.11% and with 19% replacment the strength developed is 3.65%. Further at 18% replacement it is 3.18%, at 21% it is 3.06% and finally at 22% replacement it is 1.98% which is the lowest among all. But still it is giving more strength than the conventional concrete.

Chart VI: Strength Development with respect to Conventional Concrete



6. CONCLUSION:

- The main aim of this experimental study was to plot the wider range of data which was missing due to the higher intervals in the past experimental studies i.e. evaluating the strength development around 20% cement replacement with GP from 18% to 22% with 1% interval is completed successfully.
- Further it is concluded that the highest strength development of GPC stays at 20% cement replacement followed by 19%
- The slump value of the concrete increases with increasing percentage of glass powder in concrete.
- The future scope for this experimental study can be put as; what one can do is, replace the cement from 19% to 20% with glass powder to get the optimum content of glass powder in concrete which would give optimum strength beside 20% cement replacement.

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