A Comparitive Study on The Influence of Glass Powder as Partial Replacement of Binding Material in Geopolymer Concrete and Normal Concrete In Acidic Solution

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Abstract- *Cement production process is one of the major cause of co2 emission into the atmosphere which leads to global warming. In order to reduce the environmental effects associated with these, there is a need to develop an alternative binder for producing concrete.*

Geo polymer concrete (GPC) is an innovative construction material synthesized predominantly from alumina silicate material activated by alkaline solution which emits lesser green house gas to the atmosphere. Waste glass, when ground to very fine powder shows pozzolanic properties which can be used as a partial replacement for binding material in geopolymer concrete. In this work an attempt has been made to study the effect of utilization of glass powder as partial replacement for fly ash in geo polymer concrete.

The fly ash in geo polymer concrete was replaced by glass powder in the range of 0% to 25% with an increment of 5%. All the specimens were tested for its workability, compressive strength and split tensile strength, and in acidic environment then the values are compared with those of normal fly ash-based geo polymer concrete and in Ordinary Portland Cement.

In this paper the strength of the partial replacement of the glass powder in fly ash content in the concrete mix of M40 grade. Specimens of size 150mmX150mmX150mm are utilized to check the compressive strength. Cylindrical specimen of size 150mm in breadth and 300mm length are utilized to check the Split Tensile strength. Every one of the specimens were cured for the time period of 7, 14 and 28 days for OPC concrete and 7 and 28 days for GPC concrete.it has been found that the improvement in strength in replacing of glass powder with optimum values. and finally, the specimens are also test in the 5% concentration in acidic environment for loss of weight of the specimen in the particular time period. The solution are to be consider for acidic treatment of the specimens are HCL, H2SO4, and MgSO4. These tests are conducted for 7 days and 28 days to every specimen. The test results indicated that the workability increased with increase in amount of glass powder.

Keywords- Glass powder, Ordinary Portland Cement, acidic solution, fly ash, Geo polymer concrete.

I. INTRODUCTION

The amount of concrete around the world is second only to water. Ordinary Portland Cement (OPC) is usually used as the main binder for the production of concrete. Environmental issues related to OPC production are well known. The amount of carbon dioxide released during OPC manufacturing is due to the calcination of limestone and the burning of fossil fuels in a ton order for the OPC production per ton.

In addition, the range of energy required to produce OPC is second only to steel and aluminum. On the other hand, the availability of large quantities of fly ash worldwide has created the opportunity to use this by-product to burn coal as a substitute for the OPC manufacturing of concrete. When used as part of the OPC replacement, at water and at ambient temperature, the fly ash reacts with the calcium hydroxide to form a calcium silicate hydrate (C S H) gel During the hydration process of the OPC.

An alternative cement binder known as geopolymer, including alkali-activated fly ash, is considered a replacement for OPC in order to thoroughly overhaul OPCs from construction activities. This new material, known as geopolymer, was developed by French scientist Joseph Davidovits in 1978. He defines geopolymer as an amorphous alkali metal silicate or alkali metal silicate with the composition $M_2O \cdot mAl_2O_3 \cdot nSiO_2$, usually $m \approx 1$ and $2 \leq n \leq 6$ (M is usually Na or K) Aluminosilicate binder family. In his opinion, this geo polymerization involves the chemical reaction of various aluminosilicate oxides with silicates under over based conditions, resulting in polymer Si - O - Al - O bonds.

Geopolymer

Slag is used to prepare geopolymer concrete. Known as geopolymer concrete in 100% substituting cement for industrial by-products. The technology was first developed by Davidovits in 1978. The main purpose of geopolymer Concrete is designed to reduce the consumption of cement and greenhouse gas emissions. The chemical composition of the geopolymer is similar to the zeolitic material, but the microstructure is amorphous. Any material that contains mainly amorphous silicon (Si) and aluminum (Al) is a possible starting material for the polymer in which it is produced. The use of low-calcium ASTM grade "F fly ash, blast furnace water abrasive particles in aqueous solution, alkaline solution to induce the source material dissolved silicon and aluminum atoms and form a gel, the polymerization process can be assisted by applying heat and then dried curing 60 C for 24 hours, geo-polymer gel replaces CSH gel in cement concrete.

Figure 1. Failure sample of geo polymer concrete

II. LITERATURE REVIEW

P Abhilash 2016: GGBS Hybrid FA-based GPC blends inherently have higher mechanical properties when cured at ambient room temperature without the need for heat-curing, just as with FA-based GPC blends only. In view of saving natural resources, sustainability, environment, production costs, maintenance costs and all other GPC properties, it is recommended as a low cost, innovative construction material for construction purposes.

Dr. KN Kadam 2016: Mixtures of geopolymer concrete with OPC at 3%, 6%, 9% and 12%, respectively, increased the strength over 28 days by 60.40%, 64.85%, 81.01% and 94.25% respectively over Geo Concrete and the environment cured. Geopolymer concrete with temperature cure has the highest strength, i.e., 156.65% higher than geopolymer concrete. Geopolymer concrete with OPC has better compressive strength than GPA.

N. Srujana 2017: The percent increase in compressive strength of the control coupons was 6.55%, 16.71%, 4.95%, 4.07%, and 2.3% over 7 days, compared with the ratios of 1: 2, 1: 2.5 and 1: 28 days. The percent increase in tensile strength of the 1: 2, 1: 2.5, 1: 3 ratio samples was 21%, 30.43%, 7 days, 4.0 days, 3.12% and 3.125%, 18.18%, respectively.

P. Partheeban, Ph.D., 2017: The compressive strength of geopolymer concrete paver blocks is 38.5 MPa, which is 14.4% lower than the compressive strength of M35 grade control paver blocks. Proper modification of the appropriate proportions of mixing and curing methods can improve the strength properties of the geopolymer concrete.

Pawan Anand Khanna 2017: The optimal molar concentration of KOH alkaline solution reaches the maximum compressive strength of FGPC. The optimum temperature for maximum compressive strength is 70˚C. The preferred superplasticizer content is 1.5% by weight of the binder to achieve the desired processability and maximum compressive strength.

1. Research significance

Comparison of the strength parameters of the geopolymer concrete to ordinary Portland cement with percentage replacement of fly ash with glass powder and also to determine the behavior of the concrete on acidic environment

The aim of our project is to use the glass powder as a partial replacement to concrete. Our objective is to add the glass powder to the concrete and to study the strength properties of concrete with the variation in glass powder i.e., to study the strength properties of concrete (M40 Grade) for glass powder of 0%,-25% with increment of 5% at 7 and 28 days for GPC and 7, 14 and 28 days for OPC. The strength properties being studied are as follows:

1. Compressive strength.
2. Split Tensile Strength.
3. Immersion of specimens in acid solutions.

2. Scope of work

Comparison of the strength parameters of the geopolymer concrete to ordinary Portland cement with percentage replacement of fly ash with glass powder and also to determine the behavior of the concrete on acidic environment. This study is limited to investigate the compressive strength, Split Tensile Strength and acidic treatment of geopolymer concrete specimens. The percentages are to be replaced by fly ash at 0%, 5%, 10%, 15%, 20%, and 25%.

III. TEST MATERIALS

1. Materials

The materials used in this present work are glass powder, Ordinary Portland cement (53 grade), coarse aggregates and fine aggregates.

2. Cement

Ordinary Portland Cement (OPC) is one of the most popular building materials in the world. Behind this naming of this widely used cement product is an addictive story. The name "Portland" was supplied by the British cement manufacturer Joseph Aspdin in 1824 because of its similarity to a white, gray limestone Portland stone found on Portland, Dorset, England. Joseph Aspdin is also considered the patented first real man-made cement, which he named Portland Cement.

OPC is the most commonly used type of cement in the world. OPC is the basic form of cement produced by grinding cement clinker with 3-5% gypsum, and works to raise the setting time of the cement to about 30 minutes. It can be noticed that there is no difference in chemical content between the OPC 33, OPC 43 and OPC 53 grades. The only difference is that, in the final grinding process, the higher-grade cement is more finely ground to create a stronger and more durable product than the less finely divided cement.

3. Fly ash:

Fly ash, also known as "fuel pulverized ash," is one of the coal-fired products in the United Kingdom and consists of particulate particles from the combustion exhaust gas. The ash that falls to the bottom of the boiler is called bottom ash. In modern coal-fired power plants, flue gas is typically captured by electrostatic precipitators or other particulate filtration equipment before it reaches the stack. Together with the bottom ash removed from the bottom of the boiler, it is called soot. Depending on the source and composition of the coal being burned, the composition of the fly ash varies greatly, but all fly ash includes a significant amount of amorphous and crystalline silica (SiO_2), alumina (Al_2O_3) and oxidation Calcium (CaO) containing coal rock formation of the main mineral compounds.

Fly ash from the burning of young lignite or sub-bituminous coal has some self-curing properties in addition to pozzolanic properties. In the presence of water, Class C fly ash hardens over time. Class C fly ash typically contains more than 20% lime (CaO). Unlike Class F, self-curing class C fly ash does not require activators. Class C fly ash in the alkali and sulfate (SO_4) content is usually higher.

4. Glass Powder

Basically, waste glass powder made of waste glass, due to high manufacturing costs, can no longer be used. Therefore, the manufacturer will dispose of in the landfill. Due to environmental issues, researchers are trying to use waste glass in concrete to create new materials for the construction industry. The researchers found that the main material composition of glass is silica, which is also included in the production of cement and other compounds also contained in cement production.

5. Aggregates

For a good concrete mix, the aggregate needs to be clean, hard, hard particles, free from absorbed chemicals or coatings of clay and other fine materials that can lead to concrete degradation. Aggregates accounting for 60% to 75% of the total concrete fall into two broad categories - small and thick. Fine aggregate usually consists of natural sand or gravel and most of the particles pass through a 3/8 inch screen. The coarse aggregate is any particle larger than 0.19 inches, but usually has diameters between 3/8 and 1.5 inches. Gravels make up most of the coarse aggregate used in concrete, most of which is gravel.

Fine Aggregate :

Most of the aggregates that pass through a 4.75mm mm IS sieve with a fineness modulus of 3.10 and a specific gravity of 2.70 are called fine aggregates.

Coarse Aggregate :

Aggregates with 4.75 mm remaining on the IS screen are referred to as coarse aggregate. The basic function of these polymers in geopolymer concrete is to increase the robustness of the geopolymer concrete, thereby helping to produce strong and hard geo-polymer concrete.

Figure 2. glass powder

Mix proportions

Cement	=	430kg/m3
Water	=	140kg/m3
Fine aggregate	=	660 kg/m3
Coarse aggregate	=	1178 kg/m3
Water-cement ratio	=	0.4
Alkali solution		
NaOH	=	49.14 kg/m3
Na2SiO3	=	1222.86 kg/m3

IV. EXPERIMENTAL TESTING PROCEDURE

Phase -1

Preparation of M40 OPC mix with replacement of glass powder in 0,5,10,15,20 and 25% with cement. Finding the workability and its variation for different proportions of glass powder by Slump test. Finding the 7,14 and 28 days mechanical properties like compressive and split tensile test for the mixes and knowing the optimum percentage of glass powder.

Phase -2

Preparation of M40 GPC mix with 8M fly ash alkaline ratio (from past works & literature studies) and replacement of glass powder with fly ash in 0,5,10,15,20 and 25%. Finding the variations of workability for the different proportions of glass powder by Slump test. Finding the 7,14 and 28 days mechanical properties like compressive and split tensile test for the mixes and knowing the optimum percentage of glass powder. Based on the results of Phase-1 and Phase-2 we find the optimum percentage of glass powder for OPC and GPC . After determination of optimum percentage then leads to Phase-3

Phase -3

The specimens of optimum mix in mechanical properties were immersed in water using 5% concentration of acids, sulphate and chlorides. The compressive strength and percentages of weight changes of GPC40 were compared with OPC concrete for 7 and 28 days .

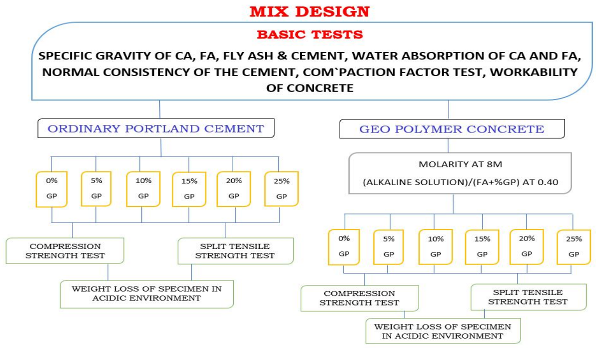

Figure 3. Schematic diagram of mix design

1. Compressive strength

Compressive strength can be defined as the ability of a material or structure to withstand loads that tend to decrease in size. In other words, it is just the opposite of the tensile strength. The main function of concrete in the structure is mainly to resist compressive forces, and due to its high compressibility and weak tensile strength, it is necessary to know its robustness so that other additions can be made accordingly. So this test is basically to understand its carrying capacity of load in compression.

Figure 4.

2. Split tensile strength:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. In this work we conduct Split Tensile Strength for various proportions of glass powder for OPC and fly ash based GPC.

Split Tensile quality (MPa) = 2P/π DL, Where, P = , D = distance across of chamber, L = length of chamber

V. RESULTS AND DISCUSSION:

1. Workability

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch.

Phase -1

The figure shows the variation of slump values of OPC having different proportions of galss powder.

Table 1.

OPC+GLASS POWDER %	SLUMP(mm)
OPC+0	41
OPC+5	53
OPC+10	59
OPC+15	63
OPC+20	67
OPC+25	71

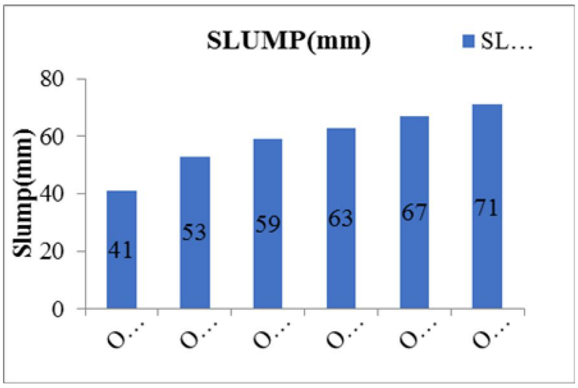

Figure 5.

Phase-2

The figure shows the variation of slump values of GPC having different proportions of glass powder.

Table 2.

GPC+GLASS POWDER	SLUMP(mm)
GPC+0	47
GPC+5	50
GPC+10	54
GPC+15	58
GPC+20	61
GPC+25	66

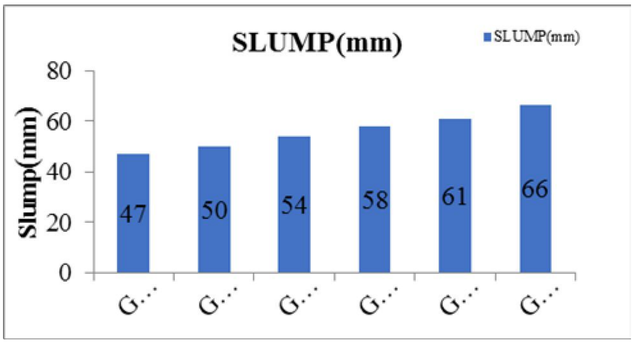

Figure 6.

Compressive strength

According to IS: 516-1959, a compressive strength was found on a 1000kN capacity Universal Testing Machine(UTM) for cubic specimens measuring 150 mm by 150 mm by 150 mm. For the compressive strength test, the loading rate used was 315 kN/m2.

The compressive test was conducted for the specimens of Phase-1 and Phase-2. For the Phase-1 specimens for curing periods of 7,14 and 28 days the compressive test was conducted For Phase-2 specimens for curing period of 7 and 28 days the compressive test was conducted.

Phase-1 Compressive Strength

In Phase-1 the compressive strength development of the various hardened Ordinary Portland concrete with different percentage of glass powder content are shown in the table.

Table 3.

OPC+GLASS POWDER	7 DAYS MPa	14 DAYS MPa	28 DAYS MPa
OPC+0	**33.8**	**38.4**	43.1
OPC+5	36.5	41.2	44.8
OPC+10	38	41.9	45.2
OPC+15	39.5	43	46.7
OPC+20	40.6	44.9	48.8
OPC+25	39.1	42.3	45.9

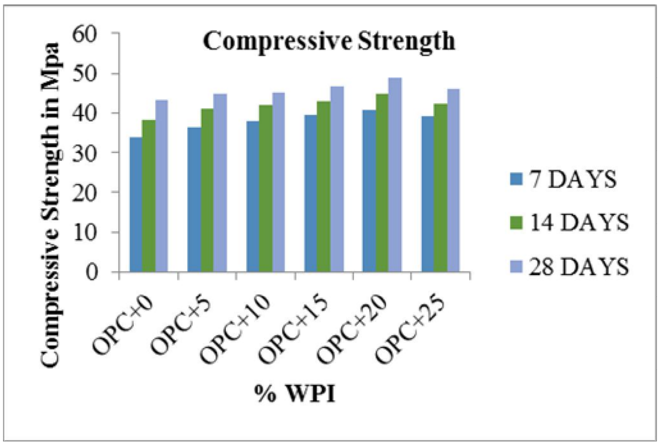

Figure 7.

Phase 2

The compressive strength development of the various hardened Geopolymer concrete with different percentage of glass powder content are shown in the table. The Geopolymer concrete. In GPC oven curing at 60 C for 24 hours and then left at room temperature. The specimens are tested for 7 and 28 days.

Table 4.

GPC+GLASS POWDER	7 DAYS	28 DAYS
GPC+0	**41.2**	43.6
GPC+5	41.8	44.3
GPC+10	42.6	45.1
GPC+15	43	46.2
GPC+20	43.7	48
GPC+25	42.9	46.4

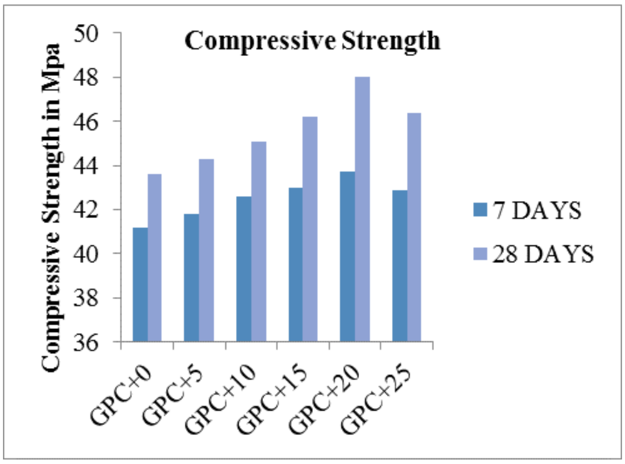

Figure 8.

Split Tensile Strength

Phase-1

The effect of glass powder on tensile strength is shown in the table. From the figure it is tensile strength is slightly influenced by glass powder. It is clear that the tensile strength was increased with glass powder content up to 20 %. Beyond 20 % the tensile strength was decreased.

Table 5.

OPC+GLASS FIBER	7 DAYS	14 DAYS	28 DAYS
OPC+0	**3.26**	**3.64**	4.09
OPC+5	3.41	3.75	4.15
OPC+10	3.65	3.98	4.3
OPC+15	3.82	4.05	4.41
OPC+20	3.97	4.18	4.63
OPC+25	3.85	4.06	4.15

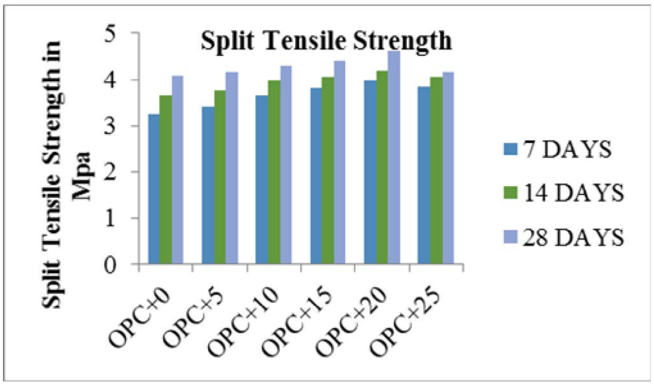

Figure 9.

Phase-2

The effect of glass powder on fly ash based geopolymer concrete on tensile strength is given below in the table. It is observed that the tensile strength increased upon addition of glass powder and decreases beyond 20% in GPC.

Table 6.

GPC+GP	7 DAYS	28 DAYS
GPC+0	4.06	4.17
GPC+5	4	4.23
GPC+10	4.18	4.45
GPC+15	4.25	4.5
GPC+20	4.38	4.63
GPC+25	4.22	4.38

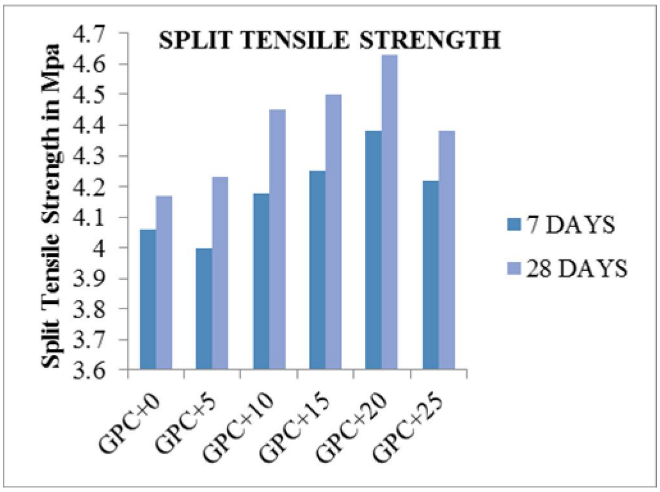

Figure 10.

The 7 day tensile strength obtained for normal fly ash based geopolymer concrete was 4.06MPa Then with the addition of glass powder up to 20% the strength was increased. The tensile strength obtained for 20% replacement was 4.38MPa. The increase of strength was 7.8% compared to that of normal GPC.

The 28 day tensile strength obtained for normal fly ash based geopolymer concrete was 4.17MPa. The tensile strength obtained for 20% replacement was 4.63MPa.The increase of strength was 11% compared to that of normal GPC.

Phase-3

From the Phase -1 and Phase-2 optimum mixes was taken and the cubes are casted. For the optimum mix in phase-1 the cubes are casted for compressive strength for 28 days water curing and the remaining cubes are immersed in 5% concentration of HCL, MgSO4 and H2SO4.

Whereas for the optimum mix in phase-2 the cubes are casted and cured in 60 oC for 24 hours after they are left for 28 days at room temperature.

Now the mixes are subjected to acidic environment 5% concentration of HCL, MgSO4 and H2SO4.

Table 7. COMPRESSIVE STRENGTH BEFORE IMMERSION

MATERIAL	28 DAYSBEFORE IMMERSION
OPC	43.10
GPC	43.60
OPC+20% GF	48.80

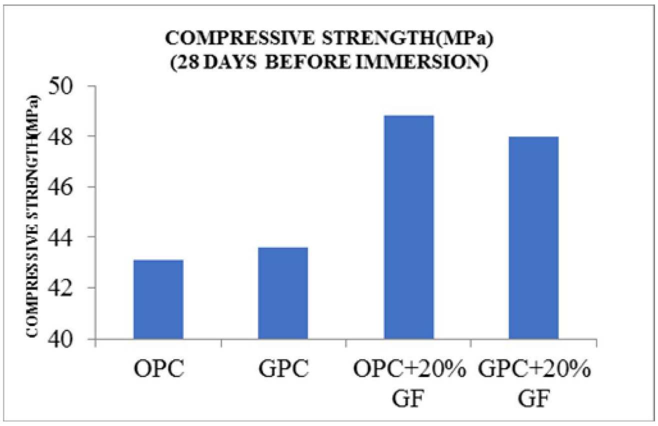

Figure 11.

Table 8. COMPRESSIVE STRENGTH AFTER IMMERSION

TYPE OF MIX	7 DAYS IMMERSION		
	HCL	MgSO4	H2SO4
OPC	41.10	40.09	34.20
GPC	42.30	48.20	40.30
OPC+20% GF	44.30	43.90	39.60
GPC+20% GF	45.00	44.20	41.30

Table 9.

TYPE OF MIX	28 DAYS IMMERSON		
	HCL	HCL	HCL
OPC	37.90	37.90	37.90
GPC	38.50	38.50	38.50
OPC+20% GF	41.50	41.50	41.50
GPC+20% GF	42.60	42.60	42.60

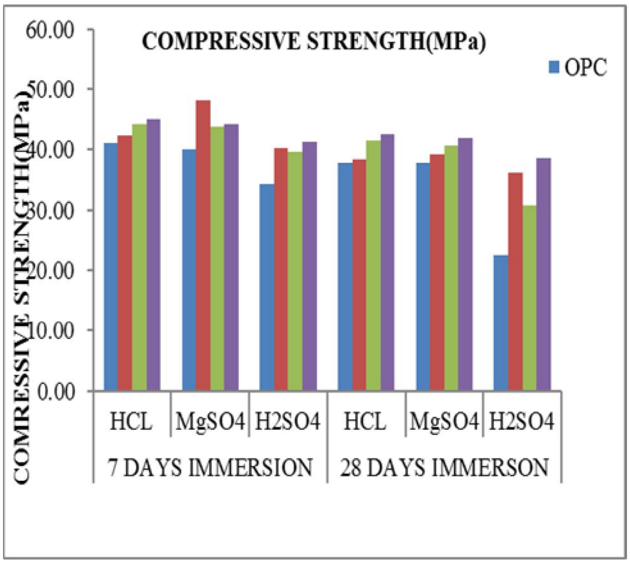

Figure 12.

Table 10. PERCENTAGE WEIGHT LOSS

TYPE OF ACID	OPC		GPC	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
HCL	41.10	40.09	37.90	37.70
$MgSO_4$	42.30	48.20	38.50	39.20
H_2SO_4	44.30	43.90	41.50	40.70

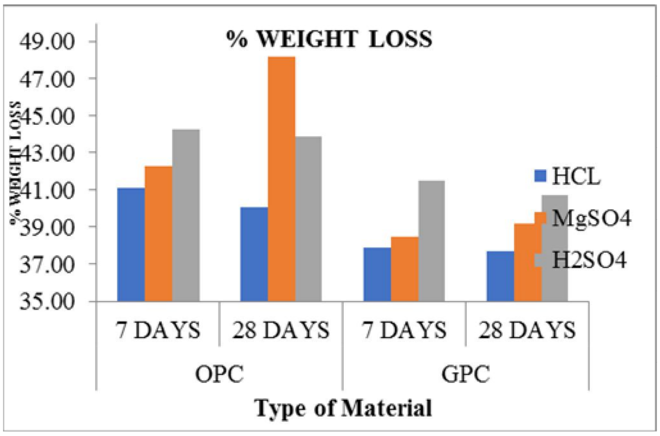

Figure 13.

The percentage weight loss was found to be more in OPC mix when immersed in MgSO4.

VI. CONCLUSIONS

1. The workability of concrete both OPC and GPC increases on addition of glass powder in 0, 5, 10,15, 20, & 25% with replacement of cement for OPC and replacement of Flyash for GPC. From the results obtained it is evident that workability increases upon addition of glass powder.
2. From the results it is clear that the OPC with 20 % replacement of cement exhibits good compressive strength compared to other mixes of OPC because of glass powder has more tendency to fill the micro ores and silica content leads to more strength.
3. For GPC with 20 %replacement of fly ash exhibits better compressive strength because of glass powder has more tendency to fill the microns inside the geopolymer concrete to increase the strength.
4. In view of tensile strength OPC with 20% replacement of cement shown better result compared to other mixes of OPC due to the high silica content.
5. For GPC with 20 %replacement of fly ash exhibits better tensile strength compared to that of other mixes.

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