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Experimental Investigation on Geopolymer Concrete by Partial Replacement of Coarse Aggregate with Ceramic Tile Waste in Ambient Curing

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Abstract - **Geopolymer concrete is one of the innovative and eco-friendly construction widely used nowadays. Although the scope of this concrete is high, the oven curing method has becomes its major issue. Inorder to overcome the disadvantage, this study aims at reviewing the part research work on making use of geopolymer concrete to be cured under normal ambient conditions for ease of the construction. In addition to this, the use of ceramic waste aggregate as possible partial substitute for conventional coarse aggregate in geopolymer concrete was also analyzed. Fly ash based geopolymer concretes were prepared by replacing 10% of fly ash with admixtures such as GGBS(Ground Granulated Blast Furnace Slag), Calcium Aluminate Cement, Alccofine and Lime. Ceramic waste such as tile waste was replaced by 30% to the natural coarse aggregate. The molarity of the NaOH solution is kept constant as 16M and the flyash to alkaline solution ratio as 2.5. Compressive strength test, Split tensile test and Flexural strength test were carried out on 7, 14 and 28 days and the results were compared with normal mix. The result specifies that the addition of admixtures in geopolymer concrete succeeds in bringing out the required strength at ambient temperature (27°C). Since, the admixtures were chosen on the basis of calcium content in them which is responsible for quick setting of the concrete, the paper conclude that only an optimum amount of calcium in the geopolymer mix can build up a strong concrete at normal temperature curing. Also, the durability characteristics of the ambient cured geopolymer specimens were studied.**

Keywords: Geopolymer concrete, ceramic tile waste, GGBS, Calcium Aluminate Cement, Alccofine, Lime

I. INTRODUCTION

The world is the risk of environmental damage to an extent. The construction industry is also not an exemption to this degradation. From the manufacture of cement till the completion of a structure, Construction industry pollutes the environment in severe ways. It is known from the studies that manufacture of cement gives off a large amount of CO_2 to the environment contributing a major portion of Green House Gases leading to the damage of Ozone layer in the atmosphere. The alternate way to control this pollution is reducing the usage of cement in construction industry and promoting a new way of construction all around. One of the emerging new technology is the Geopolymer Concrete which eliminates the usage of cement in concrete. Geopolymer concrete incorporates the use of Fly ash and chemicals such as sodium silicate and sodium hydroxide as an alternate to conventional concrete. The strength is attained by the polymerization reaction of aluminosilicate materials (fly ash) with the alkali-activating solutions. Since it is a major problem of steam curing the geopolymer concrete it is necessary to find the alternate materials to improve ambient curing. This experiment deals with the addition of admixtures such as GGBS, Alccofine, Calcium Aluminate Cement and Lime to geopolymer concrete to improve ambient curing.

Another major part of this project is the incorporation of ceramic wastes in geopolymer concrete and to analyze its performance. Ceramic Tile Wastes (CTW) are the left over tile waste from the tile shop. CTW is rich in silica and alumina [11] and are available in large pieces and hence can be replaced for coarse aggregates by crushing them. The disposal of such wastes is a major problem and thus it is mandatory to make these materials to be effectively used in construction[7]. An optimum amount of 30% of tile wastes can improve the strength properties of the concrete [16].

Thus, this project is undertaken to achieve ambient curing of the geopolymer concrete incorporating tile wastes in it for eco-friendly performance. The compressive, split tensile and the flexural behaviour of the concrete specimens were to be studied and are compared with the normal oven and ambient cured specimens. The density of the geopolymer concrete made with different admixtures were also to be analyzed and finally the durability characteristics of the specimens were to be examined.

II. MATERIALS AND METHODS

A. Materials

1. Fly Ash

In this study class F fly ash of coal by-product from Neyveli power plant is used. The specific gravity test on fly ash was conducted as per IS 4031(part 11) -1988 and the fineness was determined to be 13% [22]. The specific gravity of the fly ash used in the study is found to be 2.5. Generally fly ash particles are 1 to 10 mm in diameter with average size particle of 5.33 mm and it makes geopolymer more intact. The chemical composition of Class F fly ash is tabulated in Table 1.

TABLE 1 CHEMICAL COMPOSITION OF FLY ASH AND ADMIXTURES

Sample	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**TiO_2**	**SO_3**	**LOI**
Fly ash	65.6	28.0	3.0	1.0	1.0	0.5	0.2	0.29
GGBS	30.61	16.24	0.584	45.45	6.79	-	1.85	2.1
Calcium Aluminate cement	0.6	70.5	0.3	30.5	0.5	0.4	0.3	-
Alccofine	35.30	21.40	1.20	32.20	6.20	-	0.13	-
Lime	1.69	0.325	0.384	79.7	2.40	-	0.104	-

2. Fine Aggregate

Fine quality of natural river sand is used as fine aggregate of size 4.75 mm. Grading of fine aggregates is done using sieve analysis as per IS 2386(Part I)-1963 [24]. The fineness value is 3.8 conforming to zone II of IS 383-1970[23]. The specific gravity of the natural river sand was found to be 2.686.

3. Coarse Aggregate

The coarse aggregate used are 12.5 mm down grade crushed granite rock. The specific gravity was found to be 2.68 and the fineness value as per IS 2386(Part I)-1963 is 6.52 conforming to IS 383-1970 specifications [23, 24].

4. Ceramics

The ceramic tile wastes used in the study are usually organic and non-metallic materials mainly used as flooring tiles and wall tiles. The broken and unwanted pieces of tiles from the sellers of thickness ranging from 4 -6 mm are being collected for the project and are crushed. The crushed tiles are then graded to resemble the natural coarse aggregate in 12.5 mm and 4.75 mm sieve. The specific gravity value of these crushed aggregates is obtained as 2.5 whereas the fineness modulus as 7.1. Some of the property assessment tests such as impact test, water absorption test and natural moisture content test were also carried out.

5. Admixtures

The admixtures used here to achieve ambient curing are based on the amount of calcium content present in it. Some of the calcium rich admixtures such as GGBS, Calcium Aluminate cement, Alccofine and Lime are used. GGBS shows pozzolanic and binding properties in an alkaline medium. The addition of GGBS seems to lower the total porosity of the hardened geopolymer concrete. GGBS requires less sodium silicate solution for activation and hence lower environmental impact [14]. A standard grade of Calcium Aluminate cement with maximum CaO content of 30.5% is used, which enhance the setting properties of the geopolymer concrete. Alccofine 1203 (AF) is a microfine material which is based on low calcium silicate slag. Alccofine controls high reactivity because of controlled granulation and it also improves workability by reducing the water demand. Due to its unique chemistry and ultrafine particle size, GPC improves the strength of the concrete [9]. And the lime powder which is a rich constituent of calcium oxide is also chosen. The reactivity of lime powder to water is instant that it forms a stable compound calcium hydroxide followed by the reaction with CO_2 to form a mortar that hardens quickly.

6. Alkaline Activators

6.1. Sodium Hydroxide

The sodium hydroxide used here are available in flakes form (white colour solid) which is the dissolved in water to form the solution. The NaOH solution of 16 M was used in this study as higher concentration of NaOH contributes to higher strength.

6.2. Sodium Silicate

Sodium silicate available in a liquid gel form is used in the study. These are colourless glassy liquid with medium viscosity. The following chemical proportions corresponds to the sodium silicate solution used as the alkaline solution.

Na_2O - 7.5%-8.5%

SiO_2 - 25% -28%

Water - 67.5%-63.5%.

B. Optimum mixture determination

An optimum parametric combination to achieve required workability and maximum yield strength is determined by number of trial mixes. The factors governing the workability are significant in adopting the geopolymer concrete at field exposures. Thus the trial mixes were prepared by varying the alkaline solution ratio (Na_2SiO_3/NaOH) [17], alkaline liquid to fly ash ratio [21], molarity of the NaOH solution and the amount of water content. The specimens are cured by oven curing at 75°C. Table 2 shows the different parametric combinations for various trial mix adopted. After performing various tests on the trial mix specimens final design mix was obtained which was tabulated in Table 3.

TABLE 2 FACTORS FOR TRIAL MIXTURES

Trial mixture	**Factors**			
	Molarity of NaOH	**Alkaline liquid/ fly ash ratio**	**Na_2SiO_3/NaOH**	**Water content (lit/m^3)**
T1	12	0.3	2	43
T2		0.3	2.5	35
T3		0.6	2	35
T4		0.6	2.5	30
T5		0.8	2.5	18
T6	16	0.3	2	43
T7		0.3	2.5	35
T8		0.6	2	35
T9		0.6	2.5	30
T10		0.8	2.5	18

C. Manufacture of Geopolymer Concrete

Geopolymer concrete were made with and without the addition of admixtures for the design mix obtained from various trials. Four type of admixtures are being added to the normal fly ash based geopolymer concrete mix to improve its properties in ambient curing. Since, curing of geopolymer concrete is a long time process in ambient temperature calcium based materials were added to improve its performance. Thus five design mixes were undertaken with the notations GPC0, GPC1, GPC2, GPC3, and GPC4. GPC0 represents the normal geopolymer concrete without the addition of admixtures. GPC1, GPC2, GPC3, and GPC4 represents the addition of 10% of GGBS, Calcium Aluminate Cement, Alccofine and Lime. The mixture proportions are tabulated in Table 3.

D. Preparation casting and curing of specimen

Geopolymer concrete specimens were prepared by mixing aluminosilicate material fly ash, fine aggregate and coarse aggregate with the alkali-activating solutions prepared 24 hours before casting. The sodium hydroxide solution of 16M (Molarity) was prepared by dissolving the flakes of NaOH in water (16x40=640 grams in 1 litre of water). Sodium hydroxide of 16M molarity provides higher compressive strength as compared to 8M and 12 M [18]. Sodium silicate solution in gel form obtained from a local supplier is used. 16M NaOH solution is prepared and given a rest period of 24 h before mixing with sodium silicate solution because on mixing together the both solution polymerization takes place which liberates significant amounts of heat. The sodium hydroxide prepared 24 hours before is then added to the sodium silicate solution one hour prior to casting. The sodium silicate to sodium hydroxide ratio was maintained at a constant of 2.5 and the alkaline solution to fly ash ratio was maintained at 0.6. A constant water content of 30 kg/m^3 is used to obtain workability. The specimens after mixing are casted in 100x100x100 mm cubes and 100 mm diameter cylinders and 100x100x500 mm prisms. The casted specimens are then taken out of the mould after a day (exception for normal mix as it takes 3 days to be removed from mould) and then kept in open air at ambient temperature of 27°C to 33°C. The cured specimens are then tested for compression, split tensile and flexure at 7 days, 14 days and 28 days.

TABLE 3 DESIGN MIX PROPORTIONS INCORPORATING VARIOUS ADMIXTURES

Type of concrete	**Fly ash (kg/m^3)**	**GGBS (kg/m^3)**	**CA (kg/m^3)**	**Alccofine (kg/m^3)**	**Lime (kg/m^3)**	**FA (kg/m^3)**	**CA (kg/m^3)**	**Tiles (kg/m^3)**	**NaOH (kg/m^3)**	**Na_2SiO_3 (kg/m^3)**
GPC0	375	-	-		-	540	882	378	64.3	160.7
GPC1	337.5	37.5	-		-	540	882	378	64.3	160.7
GPC2	337.5	-	37.5		-	540	882	378	64.3	160.7
GPC3	337.5	-	-	37.5	-	540	882	378	64.3	160.7
GPC4	337.5	-	-		37.5	540	882	378	64.3	160.7

FA – Fine Aggregate, CA- Coarse Aggregate

E. Test methods

1. Workability

Workability of the geopolymer concrete is determined with the help of a slump cone of standard dimension 100 x 200 x 300 mm. The slump test were carried out as per IS 1199-1959[9]. The geopolymer concrete mix once made was poured out into the slump cone in three layers and then tamped 25 times. The cone after being filled was levelled and then raised above. The workability of the geopymer concrete can be determined from the respective height of the slump obtained. Fig.1 gives the workability of different fly ash based geopolymer concrete with different admixtures.

2. Compression strength test

The compression testing was done according to Indian Standard IS 2386 (part 4)[25]. The cubes cured under ambient temperature were tested for compressive strength at 7 days, 14 days and 28 days. Three identical specimens were tested using compressive testing machine (CTM) and the average of samples were tabulated. The compressive strength was then calculated using (1).

$$\text{Compressive strength} = \frac{P}{A}\ \text{N/mm}^2 \quad \textbf{(1)}$$

where, P = Load in N

A = Area of cube in mm^2

3. Split tensile test

Splitting tensile strength on cylinders was carried out to determine the tensile strength of the geopolymer concrete as per IS 2386 (part 4)[25]. This test is done with the help of compression testing machine(CTM). The samples of various design mix were tested for tensile strength at 7 days, 14 and 28 days and the results are tabulated. The cylinder in this test is positioned in horizontal direction and load is applied at one point along its length. The test is done on an average of three specimens and the split tensile strength is calculated using (2).

$$\text{Split tensile strength, } \mathbf{f_t} = \frac{2P}{\pi DL} \quad \textbf{(2)}$$

where, P - Compressive load at failure in N
D - Diameter of cylinder in mm
L - Length of cylinder in mm

4. Flexural strength test

Flexural Strength of Concrete is detemined using a Simple Beam with Third-Point Loading. These flexural tests (also called Modulus of Rupture tests or Third-Point Loading tests) are performed using concrete beams that have been cast and cured in the field. Center-point loading forces the beam to fail directly under the center of the loading. This may or may not be the weakest point in the beam. In third point loading, the entire middle one-third of the beam is stressed uniformly and thus the beam fails at its weakest point in the middle one-third of the beam. The flexural strength of the prism at required days were calculated using (3).

$$\text{Flextural strength, } f_{bt} = \frac{Pl}{bd^2} \quad \textbf{(3)}$$

where, P- Load at failure in N
l- Beam span in mm
b- Width of beam in mm
d- Depth of beam in mm

5. Durability test

5.1. Acid attack test

Geopolymer concrete cubes of size 100 x 100 mm were cast and cured at ambient conditions for a period of 28 days. After 28 days curing of specimens, the identified specimens were immersed in prescribed acid (HCl) solution. The solution was checked periodically for maintaining its PH value. After the required duration, the specimens were removed from the solution [20]. Using weight loss method, percentage weight loss was determined using (4).

$$\text{Weight Loss} = \frac{W_i - W_f}{W_f} \times 100 \quad \textbf{(4)}$$

where, W_i – Weight of specimen before acid attack
W_f - Weight of specimen after acid attack
The loss in compressive strength is computed from the equation (5)

$$\text{Strength loss} = \frac{F_i - F_f}{F_f} \times 100 \quad \textbf{(5)}$$

where, F_i - compressive strength after 28 days normal curing
F_f - compressive strength after 28 days HCl Curing

Figure 1 Compression Testing of cube specimen

Figure 2 Split tensile test on cylinders

Figure 3 Durability test on cube specimen

5.2. Sulphate attack test

The test was carried out on the 100 x 100 x 100 mm geopolymer concrete cube specimens. The specimens after 28 days of ambient curing were taken and their initial weights were determined. 5% of sodium sulphate (Na_2SO_4) by weight of water was measured and added with water. The specimens were taken out from the sulphate solution after 28 days of continuous soaking. The surface of the cubes were cleaned, weighed and they are tested in the compressive testing machine [20]. The percentage loss in weight and the loss in compressive strength is determined by using equations (4) and (5).

III. RESULTS AND DISCUSSION

A. Flow properties of geopolymer concrete

The slump test conducted on the fresh geopolymer concrete with and without admixtures shows that there is a slight difference in the workability of the geopolymer concrete when GGBS and Alccofine are added to it compared with the normal mix. The workability of the geopolymer concrete was a great factor to be considered for study as it is different from ordinary cement concrete instead using the chemicals for achieving bonding between materials. It can be noted that the normal mix GPC0 shows the highest workability as compared to other mixes. The workability results obtained from different design mixes were shown in Fig. 3.

The Fig. depicts the non-linear variations between the mixes which concludes that the addition of admixtures to the fly ash based geopolymer concrete render hindrance to the workability of the concrete which can be solved by the addition of water or superplasticizers. The factor alkaline solution to fly ash ratio can also be varied which enhances the workability.

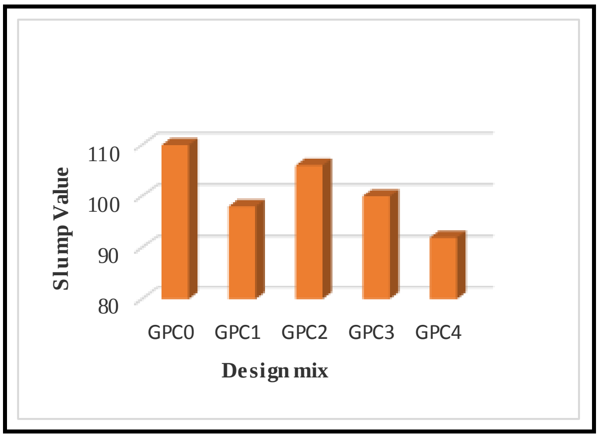

Figure 4 Workability obtained with different admixtures

B. Compressive strength

The C-S-H phase on the geopolymerization of aluminosilicates governs the compressive strength of the concrete. Fig. 4 represents the graphical representation of the compressive strength obtained for different admixtures at differernt age periods. The compressive strength results represented by the graph clearly depicts that addition of mineral admixtures in replacement of fly ash has considerably increased the compressive strength of the concrete . The fly ash replacement by GGBS has brought about 40% increase in compressive strength when compared to normal fly ash based geopolymer concrete. Similarily, Calcium Aluminate Cement and Alccofine has brought about 20% increase in their strength under ambient curing conditions. The result obtained is correlated to Pradip Nath et.al stating that the effect of additives alter the properties of concrete under ambient curing conditions[10]. The addition of GGBS has produced a higher compressive stregnth of 33.2 N/mm^2 which has a variation of about 13.3 % and 10% with the Calcium Aluminate and the Alccofine mixes. The strength variation is directly proportional to its CaO content of the admixtures. The presence of excess of CaO gives a negative impact on the concrete. On comparing with the 7 days compressive strength of oven cured geopolymer concrete cured at a temperature of 75° C for 2 days, we get a variaation of about 25% as compared to normal fly ash based geopolymer concrete cured under ambient temperature for 28 days. The oven cured geopolymer gives a strength of 30.5 N/mm2 while the Addition of GGBS to the geopolymer mix gives a higher strength of 33. 2 at the age of 28 days which provides a satisfactory result. The replacement of 30% of coarse aggregate by ceramic tile waste doe not affect the compressive strength which may be due to the presence of pozzolonic activity of very fine particles in ceramic wastes [3].

TABLE 4 COMPRESSIVE, SPLIT TENSILE AND FLEXURAL STRENGTH VARIATIONS AT AT 28 DAYS

Design Mix	Density(kg/m^3)	Compressive strength (MPa)	Tensile strength (MPa)	Flexural strength (MPa)
GPC0	2310	23.8	2.09	3.5
GPC1	2360	33.2	3.18	4.75
GPC2	2380	29	2.97	4.25
GPC3	2350	30.3	3.02	4.5
GPC4	2420	26.7	2.55	3.75

C. Split tensile strength

Splitting tensile test was a simple test conducted on cylinder specimens to The tensile strength values at 28 days for normal mix is obtained as 2.09 N/mm^2,whereas GGBS mix and Alccofine mixes were 2.97 and

3.02 N/mm^2. When GGBS is added to the geopolymer mixture, their split tensile strength has abruptly increased both at 14 days and 28 days respectively. The results represented in Fig. 5, protrays the steady increase of strength when admixtures are added to the geopolymer concrete. The split tensile strength of the GPC1 mix shows the greater value of which it can withstand tension at a higher rate compared to other mixtures. There is a 50% increase in the stength of the GPC1 mix compared to GPC0 without the addition of admixtures. The strength increase may be due to the presence of CaO, Al_2O_3 and SiO_2 in the blast furnace slag, which improves the properties of the fly ash based geopolymer concrete. The strength of GPC2 and GPC3 varies by 44% and 42% with GPC0 which is almost equal to the strength of GPC1. But the properties of lime cannot compete with the addition of GGBS, Calcium Aluminate and the Alccofine. It posses only little increase in strength compares to GPC0.

D. Flexural strength

Fig. 6 shows the variation of flexural strength of geopolymer concrete prism specimens. At the age of 7, 14 and 28 days. The flexural strength of GPC0 was achieved as 3.5 N/mm^2 at the age of 28 days whereas GPC1, GPC2, GPC3 and GPC4 achieved the strength of 4.75 N/mm^2 , 4.25 N/mm^2, 4.5 N/mm^2 and 3.75 N/mm^2 at 28 days of ambient curing. The maximum flexural strength was obtained by GPC1 which shows a greater percentage of variation from the control mix GPC0 as 35.7%. While, the other mixed such as GPC2, GPC3 and GPC4 shows a variation of 21.4%, 28.5% and 7%. The addition of ground granulated blast furnace slag not only increased the compressive and split tensile strength but also the flexural strength properties of the geopolymer concrete under ambient curing condition. The compressive strength, split tensile strength and the flexural strength values are tabulated along with their densities in Table 4.

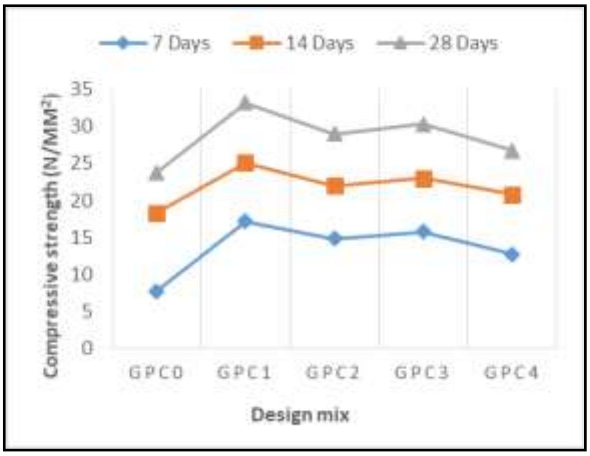

Fig 5 Compressive strength test results

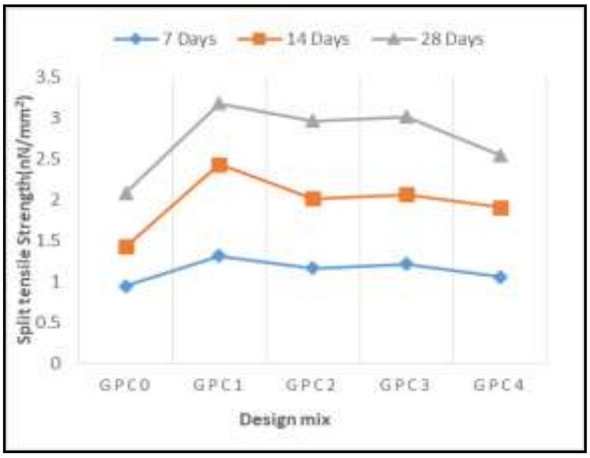

Fig 6 Split tensile test results

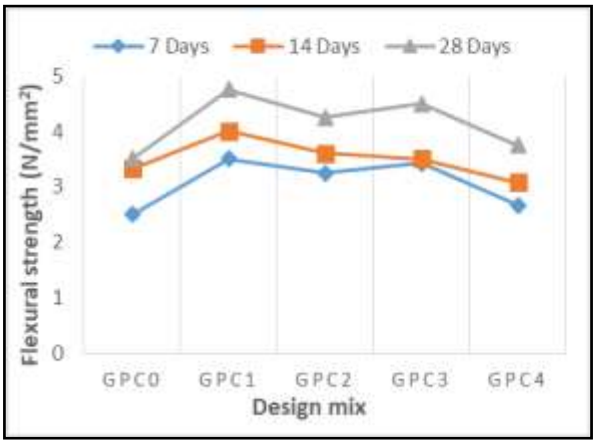

Fig 7 Flexural test results

E. Durability

1. Acid attack

The weight and the compressive strength of the specimens were found for the age of 28 days after immersion in HCl acid. The average percentage of loss of weight and compressive strengths were calculated as shown in Table 5.and Fig.8 shows the graph for the behaviour of different mixes subjected to acid curing. The graph shows a clear results regarding the weight loss percentage of comparison of the geopolymer concrete mixes with different admixtures cured under HCl for 28 days. The acid attack leads to the degradation of the concrete and thus results in weight loss and corresponding compressive strength of the specimens. It is to be noted that the impact of the acid is more on the calcium rich components. A maximum weight loss of 1.65 % is obtained on GPC4 mix in which CaO is the major component. Thus it can be inferred that the acid attack depends upon the CaO content of the concrete. Also, about half of the strength is being reduced at the end of 28 days when subjecting the geopolymer specimens to acid attack.

TABLE 5 ACID ATTACK TEST RESULTS AFTER 28 DAYS HCL CURING

Design mix	Weight before acid attack (kg)	Weight after acid attack (kg))	% loss in weight	28 days Compressive strength (N/mm^2)	% loss in strength
GPC0	2.32	2.305	0.647	17.5	26.47
GPC1	2.35	2.330	0.851	21.8	34.33
GPC2	2.36	2.320	1.48	16.8	42
GPC3	2.34	2.330	0.427	18.5	38.9
GPC4	2.43	2.390	1.65	15.0	43.8

TABLE 6 SULPHATE ATTACK TEST RESULTS AFTER 28 DAYS NA_2SO_4 CURING

Design mix	Weight before sulphate attack (kg)	Weight after sulphate attack (kg)	% loss in weight	28 days Compressive strength (N/mm^2)	% loss in strength
GPC0	2.31	2.290	1.29	14.8	37.8
GPC1	2.36	2.335	1.06	22.3	32.8
GPC2	2.38	2.340	1.68	15.2	47.5
GPC3	2.35	2.330	0.847	19.4	35.97
GPC4	2.42	2.385	1.45	15.8	40.8

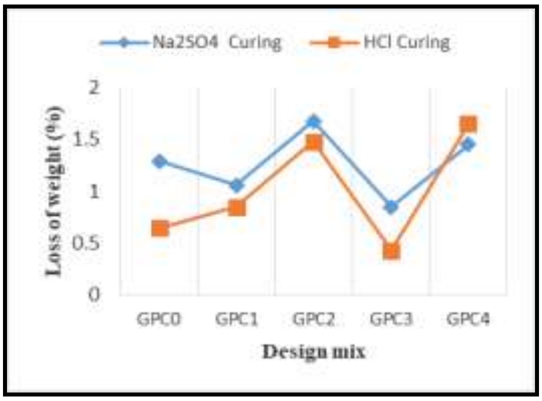

Fig 8 Percentage weight loss of specimens after acid and sulphate attack

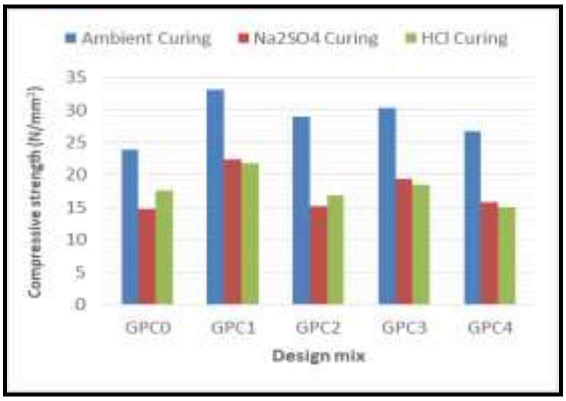

Fig 9 Effect of acid and sulphate attack on compressive strength of geopolymer concrete

2. Sulphate attack

The sulphate attack was evaluated by measuring the weight losses of the specimens at 28 days of Na_2SO_4 curing. The results for sulphate attack are shown in Table 6 and in Fig.8. The loss of weight was observed to be lower in geopolymer concrete specimen added with blast furnace slag and Alccofine when compared to Calcium Aluminate and lime geopolymer concrete mixes. A maximum weight loss of 1.68% was obtained for Calcium Aluminate cement in which CaO and Al_2O_3 are the major constituents. Sulphate attack causes the disintegration of C-S-H bonding by reacting with the Al and Ca particles of the geopolymer concrete. Thus resulting in the strength loss of the geopolymer concrete to a great percentage. A largest percentage of 47% compression strength gets lost in the sulphate attack test which should be under consideration while manufacturing geopolymer concrete.

IV. CONCLUSION

On the basis of experimental investigation carried out to study the behaviour of geopolymer concrete under ambient curing with the incorporation of ceramic tile wastes, the following conclusions are drawn. Geopolymer concrete with the addition of 30% of ceramic tile waste with calcium based admixtures greatly influence the strength and durability characteristics under ambient curing conditions. The maximum compressive strength is obtained when the flyash is replaced by 10% of GGBS (GPC2). The strength is achieved due to the presence of optimum amount of Calcium oxide in GGBS as compared to other admixtures.
The result infers that CaO in geopolymer concrete upto a certain percent renders the strength to the concrete whereas higher percentage leads to decrease in strength. The split tensile strength of the geopolymer concrete with 10% addition of blast furnaace slag shows better performance when compared to other replacements. There is a maximum of 50% variation in the split tensile strength compared to the mix added with GGBS than the other mix. The flexural strength characteristics of the ceramic contained geopolymer concrete improved with the addition of 10% of GGBS upto 35.7% on comparision with the control mix GPC0. There is a little decrease in the workability of the geopolymer concrete when the additives are added, which could be eliminated by altering the alkaline solution to fly ash ratio or by varying the water content. But the trial mix adopted shows that the strength gets considerably reduced with the increase in water content. The addition of cemntitious materials such as calcium aluminate cement and lime increase the weight and hence the density of the geopolymer specimens as compared to the addition of non-cementitious materials like GGBS and alccofine. The acid attack and the sulphate attack tests concluded that there is a little percentage of loss in the weight when subjected to acids and sulphates in which the less calcium content mixes has better resistant to the attacks. The compressive strength of geopolymer concrete specimens after subjected to acids and sulphates evince considerable decrease which is mainly owing to the reaction between the geopolymer components and the chlorides and sulphates.The addition of ceramic tile wastes does not produce much more variation with the properties of the geopolymer concrete and hence it is feasible to adopt ceramic wastes in geopolymer construction.

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