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Technical Note

DURABILITY PERFORMANCE OF VARIOUS GRADE OF GEOPOLYMER CONCRETE TO RESISTANCE OF ACID AND SALT

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ABSTRACT

It is important to durable of structure and reduce CO_2 emission through the greater use of substitute for Cement. The processing of geopolymer using fly ash, GGBS and activator solution. After making the concrete mixer of AS and aggregates, such as cube and cylinders. It is cured and tested for compressive strength. The durability of geopolymer concrete is tested by immersion in chemicals that are HCl and $MgSO_4$. Alumina-Silicate is the binder in GPC, which react with acid and salt. The different grade of concrete is used as “M20, M30, M40, M50 and M60”. These specimens are immersed separately in 5% of magnesium sulphate and 5% of hydrochloric acid with 90 days. The change of weight and strength over a 90 days for acid and salt reaction on geopolymer concrete are periodically monitoring surface deterioration and depth. The test results indicate that the geopolymer concrete has an excellent resistance to acid and sulphate attack when compared to conventional concrete.

Keywords: Geopolymer concrete; alkaline solution; magnesium sulphate; hydrochloric acid.

1. INTRODUCTION

The concrete making of binder as cement, the cement industry becomes responsible for carbendieoxide (CO_2) emissions because the production of one ton of Portland cement produces approximately one ton of CO_2 to the atmosphere [1]. Many efforts are being made in order to reduce Portland cement in concrete by means of finding alternative cementing materials such as fly ash, silica fume, ground granulated blast furnace slag, rise husk ash and

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metakaolin etc. [2] proposed an alkaline liquid that could be used to react with the silicon (Si) and aluminium (Al) to produce binders. Because the chemical reaction that takes place is a polymerization process, Davidovits coined the term "Geopolymer" to represent these binders [3]. The combination of sodium hydroxide and sodium silicate is called alkaline solution. It is found that the type of alkaline liquids is as significant factors affecting the mechanical and that the combination of silicate and sodium hydroxide gave the highest compressive strength [4]. Durability of GPC concrete is assessed by immersing separately in 5% of magnesium sulphate and 5% of hydrochloric acid with 90 days. The surface deterioration and depth of de- alkalization, changes in weight are monitored over a period of 90 days. The magnesium sulphate attack, causes decalcification of C-S-H to form magnesium silicate hydrate (M-S-H). It also destroys the binding capacity of C-S-H and leads to a loss of adhesion and strength in concrete. Wallah have shown that geopolymer composites possesses excellent durability properties in a study conducted to evaluate the long term properties of fly ash based geopolymers [5-7].

2. PREPARATION OF CONCRETE

The fly ash and alkaline solution are mixed to obtained 'geopolymer' in the ratio 0.45. The materials required for making geopolymer concrete is shown in Fig. 1. The constituents of geopolymer concrete of 8, 12 and 14 molarity sodium hydroxide for M20, M30, M40, M50 and M60 grade concrete is shown in Table 1.

Table 1: Constituents of geopolymer concrete

Description	**Material quantity (kg/m^3)**				
	M20	**M30**	**M40**	**M50**	**M60**
Fly Ash	436	410	356.25	510	264
GGBS	-	-	118.75	-	264
NaOH Solid	17.94(8)	25.30(12)	29.33(12)	36.80(14)	38.02(14)
Water	38.12	27.40	31.77	28.91	29.87
Na_2SiO_3 Solution	140.14	131.50	152.75	164.30	169.71
Coarse aggregate	1308	1230	1260	1249.50	1214.40
Fine aggregate	654	676	665	637.50	607.20
Curing 24hrs.	60° C	60° C	60° C	75° C	75° C
Super Plasticizer	-	-	2.68	3.65	4.32

In the laboratory, the fly ash, GGBS and the fine aggregates are first mixed together dry in 50litres capacity pan mixer for about three minutes. The course aggregates are prepared in saturated surface dry condition. The alkaline solution component of the mixture added to the dry materials and the mixing continued usually for another four minutes. The workability of fresh concrete is measured by means of the conventional slump test (Fig. 2). The fresh concrete could be handled up to 60 minutes without any sign of setting and without any degradation. It is observed that a geopolymer concrete stick hard to the mould so oiling the moulds is very important to release each specimen, while cast in three layers by compacting manually. Each layer received 25 strokes of compaction by standard compaction rod for concrete. The geopolymer concrete is used to cast cubes of size 100 x 100 x 100 mm and cylinders 100 mm diameter, 200 mm height as shown in Fig. 3. Fresh fly ash-based geopolymer concrete is usually cohesive. After casting the specimens, they are kept for one day in rest period at room temperature. The term ‘rest period’ is coined to indicate the time taken from the completion of casting of test specimen to the start of curing at an elevated temperature. After casting, 24 hours steam and hot air at specified temperature maintain, by the channel in curing chamber as shown in Fig. 4.

Figure 1. Materials for GPC

Figure 2. Measuring of slump

Figure 3. Casting of specimens

Figure 4. Curing chamber

3. ACID RESISTANCE

The hydrochloric acid resistance of geopolymer concrete is evaluated. To perform the acid attack in the present investigation immersion techniques is adopted [8]. After casting and curing, cubes immersed in HCl solution as shown in Fig. 5, if the concentration of HCl acid solution is 5%. The pH value of water is 6.17 and it is dropped to 5.45. The evaluation is conducted after 90 days from the date of immersion. The solution is kept at room temperature and the solution is stirred regularly. The solution is replaced at regular intervals to maintain concentration of solution throughout the test period [9]. The weight of geopolymer concrete decreases, when the acid concentration increases and the same effect is reflected after 90 days immersion in acid. The weight of GPC specimen before and after immersion is shown in Table 2.

Figure 5. HCl solution

Table 2 Weight of specimens

Grade of concrete	Initial weight of specimens (gm)		After 90 days weight of specimens (gm)	
	CC	GPC	CC	GPC
M 20	2474	2372	2398	2348
M 30	2467	2365	2453	2334
M 40	2460	2324	2441	2307
M 50	2456	2314	2413	2289
M 60	2458	2348	2426	2315

4. SULPHATE RESISTANCE

The sulphate is present in the soil in many forms such as calcium, sodium, potassium and magnesium [10, 11]. The sulphate attack is a common occurrence in natural and industrial situations. Magnesium sulphate salt of 99% purity is taken as 5%. The concentrated magnesium sulphate salt of 550g is dissolved in 11 litter of water, to keep the specimens completely immersed [12] inside the solution as shown in Fig. 6. The pH value of $MgSO_4$ solution is maintained as 7.15. The geopolymer concrete specimens after sulphate attack are shown in Fig. 7. The increase of weight and decrease of compressive strength of different grades used in GPC specimens are given in Table 3. The comparison of compressive strength of GPC specimens of different grades are shown in Fig. 9.

Table 3: Weight of specimens

Grade of concrete	Initial weight of specimens (gm)		After 90 days weight of specimens (gm)	
	CC	GPC	CC	GPC
M 20	3923	3626	3958	3647
M 30	3866	3584	3875	3553
M 40	3894	3860	3907	3827
M 50	3883	3366	3898	3342
M 60	3794	3862	3808	3835

Figure 6. $MgSO_4$ aolution

5. RESULTS AND DICUSSION

The compressive strength of cement concrete and geopolymer concrete of various grades of concrete against acid resistance of cubes Fig. 7 and test is compared in Fig. 7.

Figuer 7. After 90 days exposure

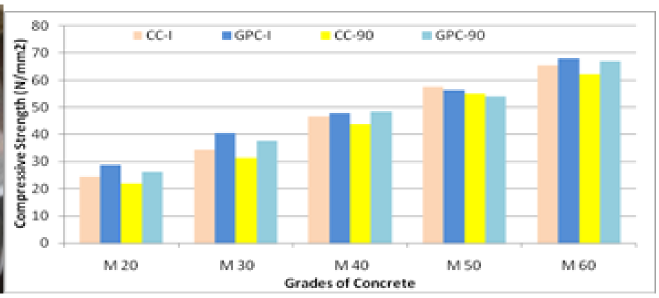

Figure 8. Comparison of compressive strength

The reduction in strength of 10.2%, 9.3%, 5.9%, 5.0% and 4.9% is observed in M 20, M 30, M 40, M 50 and M 60 grades in cement concrete respectively. The reduction in strength of 7.25%, 6.8%, 3%, 2.5% and 1.4% is observed in M 20, M 30, M 40, M 50 and M 60 grades in geopolymer concrete respectively. The compressive strength of cement concrete and geopolymer concrete of various grades of concrete against sulphate resistance of cylinder Fig. 9 and compared compressive strength in Fig. 10.

Figure 9. After 90 days exposure

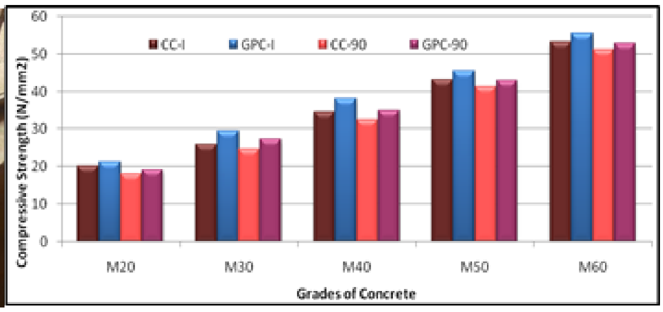

Figure 10. Comparison of compressive strength

The reduction in strength of 10.6%, 8.1%, 7.4%, 6.1%,and 5.6% is found in cement concrete of M 20, M 30, M 40, M 50 and M 60 while 9.3%, 6.3%, 6%, 5.5%, and 4.8% reduction in strength is found in geopolymer concrete of these grades.

6. CONCLUSIONS

a. The geopolymer concrete and cement concrete in different grade of concrete is minor changes in weight and strength when the specimens are exposed to hydrochloric acid and magnesium sulphate.

b. The durability of CC and GPC of various grade of concrete against 5% hydrochloric acid is found. The reduction in strength of 7.25%, 6.8%, 3%, 2.5% and 1.4% is observed in M 20, M 30, M 40, M 50 and M 60 grades in geopolymer concrete respectively. The strength reduction reduces when increase in grades of concrete.

c. The deterioration of geopolymer concrete assessed against 5% of magnesium sulphate solution and found that the weight loss and compressive strength are less when compared to cement concrete.

d. The compressive strength loss for the specimens exposed in magnesium sulphate is in the range of 5 to10% in CC, where as it was about 4 to 10% in GPC.

GPC is the industrial waste by-product for producing the binding material in concrete, so it can be considered as eco-friendly material.

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