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Evaluation of protective coatings for geopolymer mortar under aggressive environment

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Abstract. The aim of this study is to investigate the durability of fly ash based geopolymer mortar with and without protective coatings in aggressive chemical environments. The source materials for geopolymer are Fly ash and Ground Granulated Blast furnace Slag (GGBS) and they are considered in the combination of 80% & 20% respectively. Two Molarities of NaOH solution were considered such as 8M and 10M. The ratio of binder to sand and Sodium silicate to Sodium hydroxide solution (Na_2SiO_3/NaOH) are taken as 1:2 and 2 respectively. The alkaline liquid to binder ratio is 0.4. Compressive strength tests were conducted at various ages of the mortar specimens. In order to evaluate the performance of coatings on geopolymer mortar under aggressive chemical environment, the mortar specimens were coated with two different types of coatings such as epoxy and Acrylic. They were then subjected to different chemical environments by immersing them in 10% standard solutions of each ammonium nitrate, sodium chloride and sulphuric acid. Drop in compressive strength as a result of chemical exposure was considered as a measure of chemical attack and the drop in compressive strength was measured after 30 and 60 days of chemical exposure. The compressive strength results following chemical exposure indicated that the specimens containing the acrylic coating proved to be more resistant to chemical attacks. The control specimen without coating showed a much greater degree of deterioration. Therefore, the application of acrylic coating was invariably much more effective in improving the compressive strength as well as the resistance of mortar against chemical attacks. The results also indicated that among all the aggressive attacks, the sulphate environment has the most adverse effect in terms of lowering the strength.

Keywords: durability; geopolymer mortar; fly ash; Ground Granulated Blast furnace Slag; epoxy; acrylic; compressive strength

1. Introduction

Geopolymer based mortars have attracted attention nowadays in place of Portland cement based mortars because of many environmental issues related with the manufacturing of Portland cement and also due to the current focus on the sustainable construction. Fly ash based geopolymers reveal a new category of mortar which has high potential to be used in the field of concrete repair and rehabilitation. Numerous works were carried out by researchers to study the mechanical properties

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of geopolymer based mortars.

A comprehensive overview of state-of-the-art research on sustainable geopolymers for repairing deteriorated and damaged concrete structures as well as restoring their integrity was presented and the present challenges and future prospects of various geopolymer mortars as repair materials were also highlighted (Huseien *et al*. 2017). An overview of the potential fly ash based geopolymer paste for application in building construction using locally available sand blasting waste, carbide waste, shell powder, bagasse ash, rice husk and bottom ash in Indonesia was given and the fly-based geopolymer paste with locally available waste material substitution which had high temperature influence ash showed an alike nature of Ordinary Portland Cement binders that can be potentially used in various civil engineering applications (Subekti *et al*. 2017). The optimum binder to sand ratio of geopolymer mortars was determined based on mechanical properties of geopolymer mortar for various binder to sand ratios. The effect of inclusion of sand on the compressive and bonding strength of geopolymer mortar was investigated and it was found that the bonding strength of geopolymer mortar is also dependent on the various binder to sand ratios (Zailani *et al*. 2017).

The fresh and hardened properties of geopolymer mortar manufactured from fly ash and Metakaolin were investigated and a total of ten mixtures were evaluated by considering the effects of aggregates content, alkaline solution to fly ash and Metalkaolin ratio, sodium silicate to sodium hydroxide ratio, and curing method .The test results indicated that compressive strength is directly affected by the fly ash and Metakaolin content and significantly affected by the curing condition (Hameed *et al*. 2017). The compressive strength of geopolymer mortar utilizing palm oil fuel ash, fly ash, and blast furnace slag as binders and using quarry dust and manufactured sand as replacement for conventional mining sand was investigated. It was found that due to the filling and packing ability of manufactured sand, geopolymer mortar shows comparable *compressive strength* with that of mortar prepared with 100% conventional mining sand. The use of manufactured sand as fine aggregates and the use of palm oil fuel ash, blast furnace slag and fly ash as binders could be a feasible option to the conventional materials that makes up the mortar (Bashar *et al*.2016).

The effect of Multi -Walled Carbon Nanotubes (MWCNTs) on properties of slag Geopolymeric mortar was studied and the geopolymeric matrices were synthesized that contains different MWCNTs concentrations (0.0, 0.1, 0.2, 0.3 and 0.4 % by weight of the used binder). The mortar consisted of aluminosilicate slag to sand (1:2), while the alumino silicate source binder composed of 50% water cooled slag and 50% air cooled slag. It was concluded that the addition of MWCNTs enhanced the resulting amorphous geopolymer structure with marked decrease in the drying shrinkage as well as water absorption specially when using 0.1% MWCNT, while further increase in MWCNTs results in agglomeration in MWCNT within the matrix that provides hindrance in the propagation of Geopolymerization reaction and negatively affect the formed geopolymer structure (Khatera and Abd el Gawaad 2015).

An experimental program was executed to investigate the properties of ambient cured geopolymer mortar at early ages and also to set up a relationship between the composition of activator and the properties of geopolymer mortar in fresh as well as the hardened states. Test results indicated that there is potential for the concrete industry to use fly ash based geopolymer as an alternative to Portland cement (Kotwal *et al*. 2015).

A comparative study on compressive strength and internal pore structure of geopolymers with alkali activated Shirasu which is a pyroclastic flow deposit characterized by high percentage of volcanic glass and fly ash as aluminosilicates was carried out. Mix proportions of mortar were selected by varying the ratio of alkaline activators to aluminosilicate and also the ratio of silica to alkali hydroxide. From the experimental study, Shirasu geopolymer exhibited fairly good

compressive strength. The ratio of silica to alkali hydroxide was observed to have profound effect on strength development (Katpady *et al*. 2015).

The sulfuric acid attack of fly ash-based geopolymer mortar using fly ash as source material and with sodium hydroxide and sodium silicate as activators was presented. As the molar concentration of NaOH is higher the lower is the weight loss and also as the duration of immersion in sulfuric acid solution increases, the compressive strength for all specimens decreased (Saloma *et al*. 2017). The effect of alkali content in geopolymer mortar specimens manufactured from Class F fly ash exposed to Sulphuric acid was studied. The durability of fly ash based geopolymer mortars in Sulphuric acid is significantly affected by the alkali content in the activator solution and higher the alkali content, performance is better (Thokchom *et al*. 2009).

An extensive literature study was carried out to review the properties of the geopolymer mortars including fresh properties such as workability, setting time, and temperature of fresh mortar, physical properties , mechanical properties that include compressive strength, tensile strength, elastic properties, flexural performance, bonding behavior, and fracture behavior and durability properties covering acid resistance, resistance to elevated temperature, frost resistance, water absorption, and shrinkage properties (Zhang *et al*. 2018). The studies on the effect of various source materials as base materials on the properties of geopolymer mortars were also reviewed. The review on geopolymer mortars indicate that the geopolymer mortar has significant feasibility and application prospect to be used as an environmental friendly building material, which may be a suitable replacement to the traditional cement mortar in the future.

The variation in compressive strength of fly ash based geopolymer mortar by varying the molarity of sodium hydroxide was investigated. It has been found that the addition of sodium silicate enhances the strength development in geopolymer mortar. Also, there was an increase in the compressive strength with an increase in the molar concentration of sodium hydroxide and curing period (Kaur *et al*. 2018). The durability of geopolymer mortars based on waste-glass powder (WGP) and calcium aluminate cement (CAC) exposed to acid attack was studied and from the experimental investigation it was seen that, the microstructure of the geopolymer after acid exposure had exhibited substantial microcracks in the near-surface region that resulted in a greater porosity and a lower compressive strength (Vafaei and Allahverdi 2017).

The durability properties of alkali-activated slag (geopolymer) mortars were investigated and a series of test procedures such as high temperature, abrasion, rapid chloride permeability and wetting and drying cycles were performed. The results were compared with the conventional mortar made with ordinary Portland cement (OPC). The tests results revealed that the resistance of alkali-activated slag mortars under aggressive media considered for investigation was higher than that of OPC mortar (Bingol *et al*. 2020).

From the literature reviews, it can be understood that, geopolymers have few drawbacks with respect to durability particularly when exposed to acid environments. Hence there is a possibility of improving the performance of geopolymers through the application of protective coatings in order that these materials will perform well in aggressive environments. In spite of many researches available on the mechanical and durability properties of geopolymer mortar, very little information is available about the durability performance of geopolymer mortar with protective coatings. Hence an attempt has been made in the present investigation to study the performance of geopolymer mortar with and without coatings when subjected to aggressive chemical environments.

Table 1 Chemical composition of fly ash

S. No.	Characteristics	Requirements as per IS:382-2003 (% by Mass)	Test result (% by Mass)
1	$SiO_2+Al_2O_3+Fe_2O_3$	Total > 70.0	88.86
2	SiO_2	> 35.0	53.66
3	MgO	< 5.0	2.89
4	SO_3	< 5.0	0.35
5	CaO	< 5.0	0.50
6	Na_2O	--	0.36
7	Loss of ignition	< 7.0	1.02

2. Experimental program

2.1 Materials used

Fly ash is one of the most plentiful materials on the earth and also it is a vital ingredient in the making of geopolymer mortar due to its very significant role in the geopolymerization process. Class F dry fly ash with a specific gravity of 2.39 and conforming to IS 3812-2003 obtained from Tuticorin thermal power station of Tamilnadu from southern part of India was made use of in the casting of the specimens. The chemical properties of fly ash were determined at Regional Testing Laboratory Madurai and the results are shown in Table 1.

Ground Granulated Blast Furnace slag (GGBS) mainly comprises of Calcium oxide, Silicon di-oxide, Aluminium oxide and Magnesium oxide. The GGBS particles are spherical shape and white in colour. The addition of GGBS in Geopolymer mortar increases the strength of the mortar and also curing of Geo-Polymer mortar at room temperature is possible due to the addition of GGBS. For the present investigation, GGBS obtained from Quality Poly Tech, Mangalore was made use of in the preparation of test specimens and it is having a specific gravity of 2.88. The chemical properties of GGBS along with the requirements as per BS 6699:1992 are given in Table 2.

The fine aggregates used in this study was locally available river sand conforming to grading zone II as per IS: 383:1970. It was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. The bulk density, specific gravity and fineness modulus were 1670 kg/m^3, 2.7 and 2.79 respectively. Alkaline solutions used for the activation of fly ash and GGBS are a mixture of sodium hydroxide and sodium silicate solutions. Commercial grade sodium hydroxide pellets obtained from local suppliers were used to prepare solutions of desired molarity. In the present experimental investigation, two different concentrations of NaOH solutions were considered namely 8M and 10M. Sodium silicate which is available commercially in liquid form was used. The chemical composition of the sodium silicate solution is Na_2O = 8%, SiO_2 = 28%, and water = 64% by mass. Two different types of coatings namely Epoxy protective coating and Acrylic protective coatings were used to evaluate their performance in improving the properties of geopolymer mortar specimens. Epoxy protective coating with the commercial name Sikagard - 63 is a solvent free, high build thixotropic epoxy resin based protective coating designed for use on concrete and cementitious mortars. It is a two-part epoxy protective coating which consists of a resin and a hardener which is mixed in the ratio of 3: 1 respectively. Acrylic based coating is a two part acrylic polymer modified cementitious liquid applied water proofing coating system with the brand name SikaTop Seal 107.

Table 2 Chemical Composition of GGBS

S. No.	Characteristics	Requirements As per BS:6699 (% by Mass)	Test result (% by Mass)
1	Insoluble residue	< 1.5	0.4
2	Magnesia	< 14.0	7.86
3	Sulphide sulphur	< 2.0	0.5
4	Sulphite	< 2.5	0.4
5	Loss of ignition	< 3.0	0.29
6	Manganese	< 2.0	0.11
7	Chloride	< 0.1	0.008
8	Glass	> 67.0	93.0
9	Moisture content	< 1.0	0.10
10		Chemical modulus	
10a)	$CaO + MgO + SiO_2$	> 66.66	77.46
10b)	$(CaO + MgO) / SiO_2$	> 1.0	1.37
10c)	CaO / SiO_2	<1.4	1.13

The two part system consists of a white liquid and a grey powder and the resultant mixed product is cement grey in colour. It is an abrasion resistant universal coating material designed for normal to highly aggressive chemical environments. Three types of aggressive chemicals namely Sulphuric acid, Ammonium Nitrate and Sodium Chloride in 10% concentrated solutions were used to artificially produce an environment for sulphate, nitrate and chloride attacks in geopolymer mortar.

2.2 Mix design

The density of mortar is assumed as 2100 kg/m³. The ratio of binder to sand is fixed as 1:2. By fixing the alkaline liquid to binder ratio as 0.4 and from the assumed density of mortar the quantity of binder, fine aggregates and quantity of alkaline liquids was determined. The molarity of sodium hydroxide solution was kept as 8M and 10M. The binder consists of 80% fly ash and 20% GGBS. The ratio of Na_2SiO_3/NaOH is taken as 2. In order to achieve desired workability for all the mixes, extra water was added 20% by weight of cementitious material. The details of the different mix proportions are as shown in Table 3.

Table 3 Mix Proportions of Geopolymer mortar

Mix ID	Fly ash (kg/m^3)	GGBS (kg/m^3)	Fine aggregates (kg/m^3)	NaOH (kg/m^3)	Na_2SiO_3 (kg/m^3)	Alkaline liquid (kg/m^3)	Molarity of NaOH
Binder to Sand ratio 1:2, Na_2SiO_3 / NaOH = 2							
M1	494.11	185.29	1235.28	82.35	164.70	247.05	8M
M2	494.11	185.29	1235.28	82.35	164.70	247.05	10M

2.3 Preparation of specimens and test procedure

The NaOH solution was prepared the day before casting of geopolymer mortar specimens and NaOH and Na_2SiO_3 solutions of desired quantity were mixed together and stirred well. All the mixes of geopolymer mortars were mixed manually in a pan to obtain a uniform mixture. Saturated surface dry fine aggregates and the binders (fly ash and GGBS) were mixed thoroughly before adding the activator solution. Premixed alkaline activator solution was then added gradually and mixing was continued for another three to four minutes min until a consistent mixture was obtained. Fresh mortar mixture was cast in cube moulds of size 70.6 mm × 70.6 mm × 70.6 mm and the moulds were filled in two layers. Each layer was compacted by using a tamping rod of standard size, so as to avoid entrapped air inside the mortar cubes and honey combing effect on the sides. The test specimens were removed from the moulds after 24 hours of casting and left again at room temperature for ambient curing as shown in Fig. 1. The preparation process consisted of preparing two batches of specimens, the first batch being prepared with 8M concentration of NaOH solution and the other batch with 10M concentration of NaOH solution. In each batch six specimens which were not exposed to chemical solutions were tested for compressive strength and those specimens are considered as control specimens. The control specimens were tested on the same day on which the exposed specimens were tested after 30 and 60 days of exposure. Similarly, for each batch nine specimens were used for water absorption test out of which three specimens were uncoated, three specimens were provided with epoxy coating and the remaining three specimens were with acrylic coating. For water absorption test, specimens were immersed in water at room temperature for 24 hours and before which the weight of the specimens were noted. After 24 hours, the specimens were removed from water and the water is allowed to drain for 1 minute by placing them on a wire mesh. After removing visible surface water with the help of a damp cloth, the saturated weight was measured. From the difference in weight, the water absorption values were found out. For conducting durability test, 54 specimens were cast for each batch out of which 27 specimens were used to study the performance after 30 days of chemical exposure and the remaining 27 specimens were used to study the performance after 60 days of chemical exposure.

After 28 days ambient curing, protective coatings were applied to specimens and were allowed to harden over a period of five days. After the coatings had been allowed to harden over a duration of 5 days at normal room temperature and pressure, specimens were then immersed in each of 10% concentrated solutions of sulphuric acid, sodium chloride and ammonium nitrate. Care was taken so as to ensure that a minimum distance of 40 mm is maintained between the cubes placed in tubs containing acid solutions. After 30 and 60 days of chemical exposure, destructive compressive

Fig 1 Specimens under ambient curing

(a) Before immersion

(b) After immersion

Fig. 2 Specimens immersed in 10% H_2SO_4, NaCl and NH_4NO_3 solutions

(a) 30 days exposure

(b) 60 days exposure

Fig. 3 Specimens after H_2SO_4 exposure

(a) 30 days exposure

(b) 60 days exposure

Fig. 4 Specimens after NaCl exposure

strength test was performed by using Compression Testing Machine in order to monitor the drop in compressive strength. After exposure, the percentage loss in weight of the specimens was also calculated by noting the difference in weight of mortar cube specimens before and after immersion in acid solutions. Uncoated Specimens, Epoxy and acrylic coated specimens before and during immersion are shown in Figs. 2(a) and (b) respectively. The visual appearance of the specimens after immersion in 10% H_2SO_4, NaCl and NH_4NO_3 solutions are shown in Figs. 3-5. From the figures, it was noticed that specimens did not show major deterioration after chemical exposure except certain colour changes.

(a) 30 days exposure (b) 60 days exposure

Fig. 5 Specimens after NH_4NO_3 exposure

3. Resuts and discussion

3.1 Water absorption

The test results of water absorption for all the specimens tested are given in Table 4. From the results, it can be seen that the uncoated specimens exhibited the maximum water absorption as compared to the specimens applied with coating. This trend is applicable for both specimens

Table 4 Water absorption

Type of coat	Molarity of NaOH	Dry weight (in gm)	Weight after immersion in water (in gm)	Water absorption in %	Avg. Water absorption in %
Without coat	8M	730	810	9.8	9.8
		737	812	9.2	
		740	825	10.3	
	10M	765	850	10.0	10.5
		770	860	10.5	
		775	870	10.9	
Epoxy	8M	810	850	4.7	5.1
		817	867	5.7	
		820	862	4.9	
	10M	845	893	5.4	5.0
		857	906	5.4	
		860	898	4.2	
Acrylic	8M	812	837	2.9	2.8
		820	845	2.9	
		825	848	2.7	
	10M	848	878	3.5	3.0
		853	879	2.9	
		861	884	2.6	

prepared with both 8M and 10M NaOH solutions. As far as the type of coating is considered, specimens with acrylic coating absorbs less water when compared to mortar specimens with epoxy coating. This may be due to the reason that acrylic coating might have filled the pores in the mortar surface effectively and thereby did not allow the penetration of water inside the specimens. For both the molarity of NaOH solutions, acrylic coating showed better performance with respect to water absorption as compared to epoxy coated specimens.

3.2 Effect of exposure on compressive strength

The compressive strength results of mortar specimens after subjected to 30 and 60 days of chemical exposure in three different chemical environments are given in Tables 5 and 6 for 8M and 10M specimens respectively. The effect of types of coating, number of days of exposure and the type of exposure on the compressive strength is discussed. From the test results it can be found that as the concentration of NaOH solution increases, the compressive strength also increases. The loss in compressive strength of specimens after subjecting them to 30 days and 60 days of chemical

Table 5 Compressive strength – 8M specimens

S.No.	Type of coat	No. of days of exposure	Avg. ultimate load in kN			Avg. compressive strength (N/mm^2)		
			8M			8M		
			Sulphate	Chloride	Nitrate	Sulphate	Chloride	Nitrate
1	-	-		137.87		27.66 (No exposure)		
2	-	30	96.47	104.87	108.5	19.35	21.04	21.77
3	Epoxy	30	110.27	116.97	121.1	22.12	23.47	24.30
4	Acrylic	30	115.77	124.67	126.57	23.23	25.01	25.39
5	-	-		142.43		28.58 (No exposure)		
6	-	60	84.5	96.63	106.03	16.95	19.39	21.27
7	Epoxy	60	98.53	106.97	125.17	19.77	21.46	25.11
8	Acrylic	60	107.93	116.67	134.07	21.65	23.41	26.90

Table 6 Compressive strength – 10M specimens

S. No.	Type of coat	No. of days of exposure	Avg. ultimate load in kN			Avg. compressive strength (N/mm^2)		
			8M			8M		
			Sulphate	Chloride	Nitrate	Sulphate	Chloride	Nitrate
1	-	-		152.5		30.60 (No exposure)		
2	-	30	105.73	116.4	120.4	21.21	23.35	24.16
3	Epoxy	30	123.2	131.3	133.43	24.72	26.34	26.77
4	Acrylic	30	129.73	137.53	142.2	26.03	27.59	28.53
5	-	-		154.95		31.09 (No exposure)		
6	-	60	94.93	107.57	106.03	19.05	21.58	21.27
7	Epoxy	60	109.73	119.3	125.17	22.01	23.93	25.11
8	Acrylic	60	118.93	127.83	134.07	23.86	25.65	26.90

exposure for various molarity of NaOH solutions are shown in Figs. 6-9. Test results indicated that the uncoated specimens suffered a maximum loss in compressive strength when subjected to chemical exposure when compared to control specimens without any exposure. As the number of days of exposure increases from 30 days to 60 days, the compressive strength drops further for both the molarities of NaOH and also for all the types of exposure.

Initial compressive strength of the control specimen (8M) is 27.66 N/mm^2 and it experienced a drop in strength of 30.04% in sulphate environment, 23.93% strength drop in chloride environment and 21.29% strength drop in nitrate environment after 30 days of exposure. Similarly, after 60 days of chemical exposure, specimens suffered 40.69% drop in strength in sulphate environment, 32.16% strength drop in chloride environment and 25.58% strength drop in nitrate environment against the initial strength of control specimen being 28.58 N/mm^2. The above trend of drop in strength is almost similar for specimens made with 10M NaOH solution. Drop in strength was estimated to be 30.69%, 23.69% and 21.05% for exposure in sulphate, chloride and nitrate environments respectively after 30 days of exposure and after 60 days of exposure, the decline in compressive strength was found to be 38.73%, 30.59% and 31.59% respectively for sulphate, chloride and nitrate environments. From the results it can be inferred that sulphate environment is the most aggressive environment for control specimens, as it showed maximum loss in compressive strength. Nitrate environment is the least aggressive environment for mortar batches, whereas the chloride environment has intermediate aggressiveness.

On the other hand, in case of specimens coated with epoxy and acrylic, the loss in compressive strength is less when compared to uncoated specimens. However, among the types of coating considered in these investigations acrylic coated specimens performed better in comparison with epoxy coated specimens by exhibiting a minimum drop in compressive strength. Acrylic coatings are effective under all chemical exposures when compared to epoxy coatings. As far as the type of exposure for coated specimens is concerned, nitrate exposure has least deleterious effect which exhibited a minor loss in compressive strength of 8.21% and 5.88% after 30 and 60 days of exposure respectively for specimens prepared with 8 Molarity of Sodium Hydroxide solutions. The loss in strength is minimum for 10M NaOH specimens also under nitrate exposed conditions. The sulphate exposure has such an adverse effect on geopolymer mortar specimens prepared using 8M NaOH solutions because the compressive strength of uncoated specimens and specimens that were coated with epoxy drops below 20N/mm^2 against the initial strength of 28.58 N/mm^2.

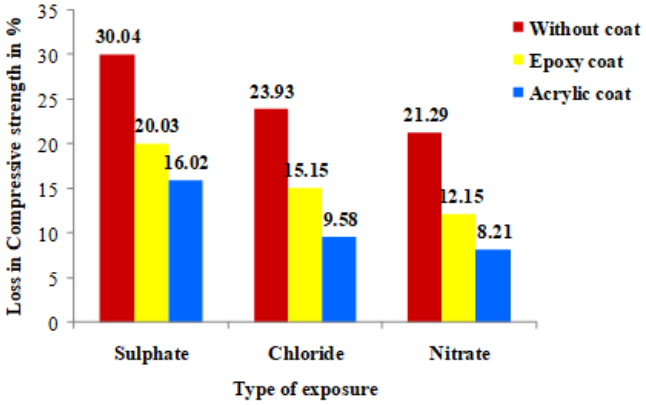

Fig. 6 Compressive strength loss – 8M and 30 days exposure

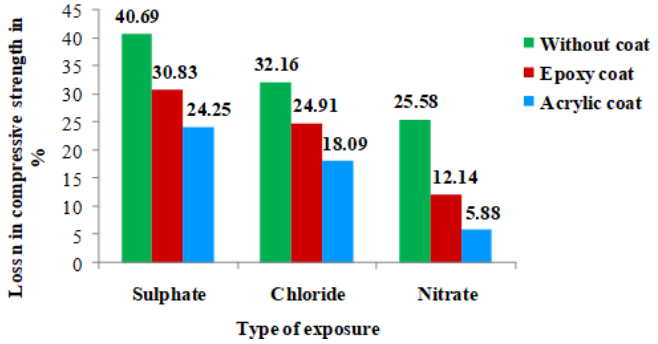

Fig. 7 Compressive strength loss – 8M and 60 days exposure

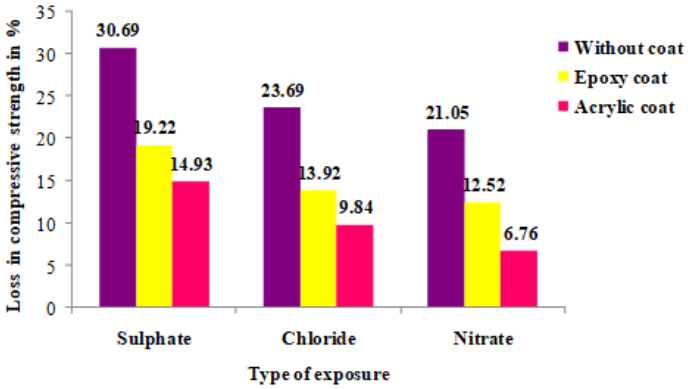

Fig. 8 Compressive strength loss – 10M and 30 days exposure

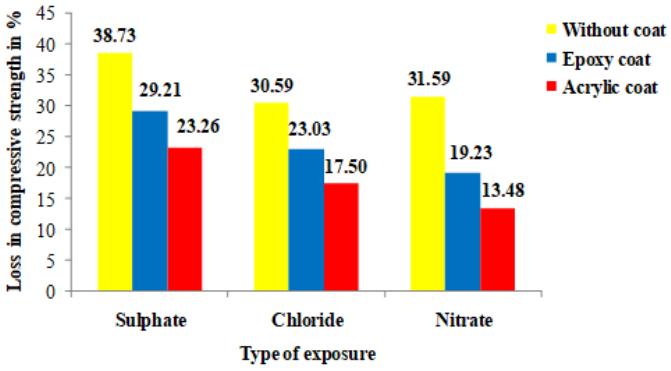

Fig. 9 Compressive strength loss – 10M and 60 days exposure

3.3 Loss in weight due to chemical exposure

Mortar specimens were immersed in 10% solutions of sulphuric acid, Sodium sulphate and Sodium chloride for a test period of 30 days and 60 days. The change in weight of geopolymer mortar cubes after exposure was observed for both coated and uncoated specimens. All the exposed specimens recorded weight loss and it was observed that the weight loss due to sulphate environment

Table 7 Weight loss after exposure

S. No.	Type of coat	No. of days of exposure	Avg. Loss in weight in %			Avg. Loss in weight in %		
			8M			10M		
			Sulphate	Chloride	Nitrate	Sulphate	Chloride	Nitrate
1	-	30	1.63	0.78	0.50	1.56	0.74	0.52
2	Epoxy	30	1.07	0.66	0.37	1.02	0.39	0.35
3	Acrylic	30	0.82	0.46	0.29	0.78	0.39	0.27
4	-	60	2.67	1.37	1.10	2.12	1.30	0.95
5	Epoxy	60	1.82	1.11	0.83	1.55	1.06	0.74
6	Acrylic	60	1.35	0.95	0.75	1.08	0.82	0.62

is more in comparison to chloride and nitrate exposures. The uncoated specimens show minimum loss in weight of 0.5% and 0.52% for 8M and 10M specimens respectively after 30 days in nitrate environment. The loss in weight for uncoated specimens is about 1.1% and 0.95% for 8M and 10M specimens respectively after 60 days in nitrate environment. The maximum loss in weight for uncoated specimens is noted as 1.63% after 30 days and 2.67% after 60 days in sulphate environment for 8M specimens. For 10M specimens also, the uncoated specimens suffered due to maximum loss in weight in sulphate environment. In general, acrylic coated specimens shows minimum loss in weight offering the better resistance in all the environments.

4. Conclusions

Based on the experimental investigations carried out, the following conclusions are drawn:

- Geopolymer mortar has least resistance to sulphate attack since they suffered a huge weight loss after exposure and hence there is a major drop in compressive strength also.
- Mortar prepared with fly ash and GGBS has better resistance in nitrate environment
- Durability performance is enhanced in geopolymer mortars when protective coatings were applied to them
- Acrylic coatings are superior in enhancing the durability in nitrate, sulphate and chloride environments when compared to epoxy coatings.
- As the molarity of sodium hydroxide solution increases, the resistance against the aggressive chemicals also increases, since the drop in compressive strength and loss in weight of 10M specimens are comparatively lesser than that of 8M specimens.

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