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A STUDY ON DURABILITY PROPERTIES OF HIGH STRENGTH CONCRETE BY EFFECT WITH MINERAL ADMIXTURES IN AGGRESSIVE ENVIRONMENT

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ABSTRACT

Concrete is the most commonly used construction material. The premature deterioration of concrete structures in aggressive environments has led to the development of high performance concrete (HPC). The production of HPC involves appropriate selection and proportioning of the constituents to produce a composite mainly characterised by its low porosity and fine pore structure. These, in turn improve the resistance of concrete to the penetration of harmful substances such as chloride and sulphate ions, carbon dioxide, water and oxygen, and hence enhance durability performance. The improved pore structure of HPC is mainly achieved by the use of chemical and mineral admixtures. In the present study the effect of mineral admixtures on the durability properties of HPC is investigated. A control mix without any mineral admixtures having a compressive strength was designed of 60MPa and two other mixes are prepared one by replacing cement by 10% metakaoline and other by replacing cement with 10% metakaoline + 30% fly ash respectively The workability tests were carried out on the fresh mix. Durability properties were determined by conducting sulphate attack test, acid attack test and rapid chloride permeability test.

Keywords – deterioration, high performance concrete, mineral admixtures.

I.INTRODUCTION

High-performance concrete is defined as concrete that meets special performance and uniformity requirements that cannot always be achieved routinely by using conventional materials and normal mixing, placing, and curing practices. Thus, a high-performance concrete is a concrete in which certain characteristics are developed for a particular application and environment. For example, concrete that provides substantially improved durability under severe service conditions, extraordinary properties at earlier ages, or substantially enhanced mechanical properties are potential HPCs. These concretes may contain materials such as fly ash, silica fume, ground granulated slags, natural pozzolan, fibers, chemical admixtures, and other materials, individually or in various combinations. From a structural design standpoint, high performance concrete allows more slender structural elements with greater rigidity (higher modulus of elasticity) for smaller deflection, less creep, and a high MPa/$ ratio. Unfortunately, very few material building codes have provisions for high-performance concrete at present. One of the main causes of deterioration in concrete structures is the corrosion of concrete due to its exposure to harmful chemicals that may be found in nature such as in some ground waters, industrial effluents and sea waters. The most aggressive chemicals that affect the long term durability of concrete structures are the chlorides and sulfates. The chloride dissolved in waters increase the rate of leaching of portlandite and thus increases the porosity of concrete, and leads to loss of stiffness and strength. Calcium, sodium, magnesium, and ammonium sulfates are in increasing order of hazard harmful to concrete as they react with hydrated cement paste leading to expansion, cracking, spalling and loss of strength. The rate at which the hardened cement paste is deteriorated due to the exposure to harmful chemicals depends mainly on the concentration of the chemicals in water, the time of exposure and the chemical resistance of concrete. Extensive investigations have been carried out on the use of fly ash and silica fume in concrete during the past two decades and have consequently led to their widespread application in the construction industry. Many national standards also exist which determine the degree of attack, and this primarily on the basis of the concentration of the aggressive substances. However, the chemical resistance of high performance concrete using metakao line, fly ash and super plasticizers are issues which have not yet received sufficient attention from the research community. In the present study the effect of various mineral admixtures on the durability properties of HPC is being investigated.

II. MATERIALS

Portland cement of 53 grade manufactured by Krishna nagar Company confirming to IS 12269 was used in this investigation. The specific gravity of the cement was 3.01. The initial and final setting times

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were found as 70 minutes and 240 minutes respectively. Locally available river sand passing through 4.75 mm IS. Sieve was used. The specific gravity of the sand is found to be 2.47.Crushed granite aggregate available from local sources has been used. To obtain a reasonably good grading, 50% of the aggregate passing through 25mm I.S.sieve and retained on 20mm I.S.sieve and 50% of the aggregate passing through 20 mm I.S.sieve and retained on 12 mm I.S.sieve was used in the production of HPC. In the production of M60 grade concrete, 20mm maximum size coarse aggregate has been used. The specific gravity of coarse aggregate is 2.76. Potable fresh water available from local sources was used for mixing and curing of both HPC mixes and M60 grade concrete. To improve the workability of the HPC mixes, a high range water-reducing agent Auromix has been used in the present work. The mineral admixture metakaoline is obtained from English indian clay limited company at Trivandrum. The specific gravity of Metakaolin is 2.6. The Metakaolin is in conformity with the general requirements of pozzolana..FA was supplied by National Power from Drax Power Station and conformed to BS 3892

III. CONCRETE MIXES

The constituents of the OPC mix were proportioned to achieve maximum packing of the particles and thus minimum porosity The composition of the OPC mix was 1:1.63:2.6 by weight of cement: sand: gravel, with a cement content of 450 kg/m3.For the MK and FA concrete mixes, 10% and 30% by weight of the OPC were replaced by MK and FA, respectively. A high superplasticiser dosage was used, and the amount of mixing water was decided on the basis of equal workability. The w/b ratio was 0.303for all the 3 mixes concrete mixes. The workability of the concrete mixes ranged between 180 and 190 mm as obtained by the slump test.

IV. TEST SPECIMENS

Standard moulds were used for casting 150mm cube specimen. which includes cubes of size 150mm x 150mm x 150mm, discs of size 100mmdia x50mm thick were cast. For durability study specimens were kept in respective solutions till the test ages are reached. These specimens were tested for different mechanical properties and durability properties. Mixing was done in a laboratory type pan mixer. Pan mixers with revolving star of blades were used. While preparation of HPC aggregates, cement and mineral admixtures were mixed in the revolving pan. After proper mixing, mixture of water and plasticizer was added. The mixing was continued until a uniform mix was obtained. The concrete was then placed into the moulds which were properly oiled. After placing of concrete in moulds proper compaction was given. Specimens were demoulded after 24 hours of casting and were kept in a curing tank for water curing.

V. LITERATURE REVIEW

1. Alexander et al.(1999) This document discusses the effect on concrete of condensed silica fume(CSF) as well as the durability of the concrete contained in this condensed silica fume. This document describes a short-term survey to examine the durability efficiency of different concentrations of condensed silica fume concrete compared to portland cement (PC) and PC controls with floor granulated blast furnace slag (GGBS) up to 28 days of era. Mix proportions were designed to provide 30 MPa, 40MPa and 50 MPa for a 28 day intensity. Tests of durability index by name water soptivity, conductivity of chloride and permeability of oxygen were carried out. Control mix with OPC and no admixture, OPC with 50 percent GGBS replacement, OPC with 5 percent CSF substitute, OPC with 10 percent CSF replacement, OPC with 10 percent CSF addition, using 3 distinct water binding ratios namely 0.66, 0.56 and 0.49, mix comprising 50 percent OPC, 40 percent GGBS and 10 percent CSF were prepared. The blend comprising OPC with the addition of 10 percent CSF showed that resulting from 52 percent lower water sorptivity than control mix and also 75 percent lower chloride conductivity than and control mix. For all the W / C ratios of all the mixes, the remaining index which is oxygen permeability is not much affected. Coming to the substitute condition of moist curing. The inference from this paper is that, addition of condensed silica fume to the concrete can give better performance instead of being when it is replaced for cement.

2. Michel Mbessa et al.(2001). Investigated the trait of durability in ammonium sulphate solution for high-strength concrete. The authors inferred from the past research and investigations that, compared to metakaolin, silica fume was more effective in terms of concrete resistance to ammonium sulphate at 10 percent Portland cement replacement level. Therefore, in this study, a comparison was created between standard concrete and high-strength concrete (HSC) made of silica fume, metacaolin and ground granulated slag at a substitute rate of 10 percent cement. A high-strength concrete with a performance of 28 days of 100 MPa was explored in this research. An accelerated attack composed of wetting-drying cycles is one more thing taken throughout the job in this research. Some of the distinctive differences such as mass loss, compressive strength, and changes in length were evaluated before and after the sulphate assault. A microstructure inquiry was carried out using scanning electron microscopy (SEM). The outcome of mass loss showed that the HSC with

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silica fume suffered 24 percent less mass loss after 6 cycles of wetting and drying compared to standard concrete without admixture. However, no compressive strength degradation of concrete occurred regardless of the concrete structure. But in conventional concrete, the variation in length i.e. shrinkage was 30% less than in silica fume concrete, in the sense that shrinkage is 30% more in SFC. In this document it explains that while the silica fume concrete showed better efficiency, resulting in mass loss and compressive strength, it endured backlog owing to greater shrinkage compared to other metakaolin-consisting concrete. But, because of the percentage of shrinkage, it can be considered as the best admixture for concrete subject to sulphate environment.

3. Lee et al.(2005), Investigations were carried out on the sulfate attack and the role of silica fume in resisting weight loss and strength. The writers recognized from prior works that resistance to sulphate can be brought to concrete by adding silica fume to it. This document discusses the thorough experimental study on Portland cement mortars ' sulphate assault and the controlling nature and efficacy of silica fume to avoid harm from such an assault. The test solutions were used to impart sulfate ions and cations with 5% magnesium sulphate solution and 5% sodium sulphate solution. By its mass, the replacement of cement was performed by Silica fume in 5%, 10% and 15%. The primary factors such as cement replacement rate and water / cementitious materials ratio have been explored in this research. The compressive resistance measured on 50 mm3 size cubes will be used to study and evaluate modifications in the mechanical characteristics of mortar samples that are subjected to sulphate attack for 510 days. This provides a sample outcome that, owing to the impact of sodium sulphate, the existence of silica fume had a benefit and beneficial impact on the loss of strength. The concrete produced after being immersed in sulphate solution for 500 days with 15 percent replacement of cement with silica fume has 75 percent lower compressive strength loss than standard concrete without replacement.

VI MATERIAL COMPOSITION

Parameters	Mix Reference			
	Conventional	SFC	FAC	FASFC
Cement ,kg/m3	591	473	414	280
Silica fume	-	118	-	118
Fly ash	-	-	177	177
Fine aggregate	744.57	744.57	744.57	744.57
Coarse aggregate	1049.57	1049.57	1049.57	1049.57
Super plasticiser	49	49	49	49
Water	148	148	148	148
W/C	0.25	0.25	0.25	0.25
Mix ratio	1:1.25:1.77			

FIG 1 Mix Proportioning

VII TEST PROCUDURES

Durability:

Durability is defined as its ability to resists weathering action, chemical attack, abrasion, or any other process of deterioration; that is durable concrete will regain its original form, quality, and serviceability when exposed to its environment

TEST ON ACID ATTACK OF HIGH STRENGTH CONCRETE

First of all, concrete containing Portland cement, being highly alkaline, is not resistant to attack by strong acids or compounds which may convert to acids. Chemical attack of concrete occurs by way of decomposition of the products of hydration and formation of new compounds which, if insoluble, may be leached out and, if not soluble may be disruptive in situ the attaching compounds must to be in solution. The most vulnerable cement hydrate is Ca(OH)2 and C-S-H can also be attached calcareous aggregates are also vulnerable.

Test on alkali attack of high strength concrete

Acid assault is chosen by inundating check examples of size 150 X 150 X 150 metric straight unit shapes in 10% Na2SO4severally. The crumbling of examples zone unit introduced inside the assortment of offer decrease in weight and rate diminishment in compressive strength at 28 days

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VIII.RESULT AND DISUSSIONS

Table 1. compressive strength of M100 at different ages

Grade of concrete	*Compressive strength at different ages*							
	1 days	*3 days*	*7days*	*14days*	*28 days*	*56 days*	*90 days*	*180 days*
M100	*18.5*	*43.3*	*69.7*	*87.5*	*103.4*	*110.74*	*124.08*	*128.45*

Table 2. Weight after immersing in 10% HCL solution

S.No	Mix ID	Weight before immersing in 10% of HCL solution	Weight after immersing in 10% HCL solution			
			28 days	56 days	90 days	180 days
1	Conventional	8.30	7.995	7.93	7.83	7.79
2	SFC	8.55	8.37	8.192	8.09	8.05
3	FAC	8.36	8.14	8.001	7.93	7.85
4	FASFC	8.36	8.16	8.008	7.908	7.86

Table 3. Weight after immersing in 10% H2SO4 solution

S.No	Mix ID	Weight before immersing in 10% of H2SO4 solution	Weight after immersing in 10% H2SO4 solution			
			28 days	56 days	90 days	180 days
1	Conventional	8.35	6.969	6.69	6.315	5.917
2	SFC	8.61	7.524	7.37	7.074	6.683
3	FAC	8.39	7.16	6.972	6.78	6.385
4	FASFC	8.392	7.26	7.067	6.850	6.45

Table 4. Weight after immersing in 10% Na2SO4 solution

S.No	Mix ID	Weight before immersing in 10% of Na2SO4 solution	Weight after immersing in 10% Na2SO4 solution			
			28 days	56 days	90 days	180 days
1	Conventional	8.321	8.224	8.221	8.220	8.218
2	SFC	8.446	8.439	8.422	8.414	8.407
3	FAC	8.321	8.306	8.304	8.296	8.286
4	FASFC	8.48	8.47	8.461	8.451	8.441

Table 5. weight of different concrete mix in acid and base curing-D-days

Grade of Concrete	10% HCl solution				10% Na2So4 solution				10% H2So4 solution			
	28	56	90	180	28	56	90	180	28	56	90	180
Conventional	3.67	4.45	5.6	6.14	1.16	1.2	1.213	1.23	16.5	19.88	24.36	29.13
SFC	2.10	4.18	5.38	5.84	0.082	0.28	0.37	0.46	12.6	14.40	17.83	22.37
FAC	2.63	4.29	5.5	6.1	0.18	0.206	0.309	0.42	14.66	16.89	19.13	23.89
FASFC	2.39	4.21	5.4	5.98	0.11	0.213	0.332	0.45	13.48	15.78	18.37	23.13

Table 6. Compressive strength in MPa after immersing in 10% HCL solution

S.No	Mix ID	Ultimate load in MPa	Compressive strength in MPa after immersing in 10% HCL solution			
			28 days	56 days	90 days	180 days
1	Conventional	103.4	84.43	84.068	83.62	83.28

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2	SFC	111.98	95.432	95.09	94.70	94.4
3	FAC	110.86	93.30	92.86	91.89	91.08
4	FASFC	110.92	93.96	93.67	92.97	92.42

Table 7. Compressive strength in MPa after immersing in 10% H2SO4 solution

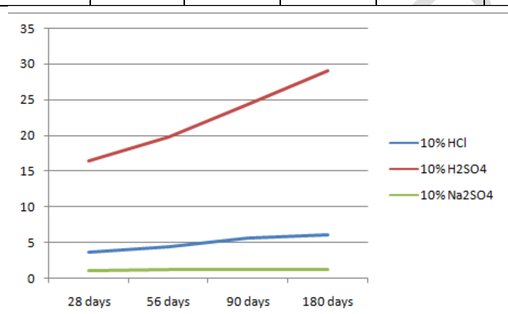
S.No	Mix ID	Ultimate load in MPa	Compressive strength in MPa after immersing in 10% H2SO4 solution			
			28 days	56 days	90 days	180 days
1	Conventional	103.4	69.79	62.25	56.47	50.53
2	SFC	111.98	83.64	76.30	68.99	59.69
3	FAC	110.86	79.44	72.45	66.37	56.66
4	FASFC	110.92	80.55	74.194	66.97	58.64

Table 8. Compressive strength in MPa after immersing in 10% Na2SO4 solution

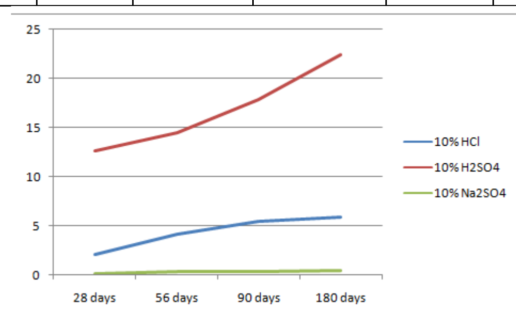
S.No	Mix ID	Ultimate load in MPa	Compressive strength in MPa after immersing in 10% Na2SO4 solution			
			28 days	56 days	90 days	180 days
1	Conventional	103.4	97.972	97.93	97.87	97.81
2	SFC	111.98	109.28	109.225	109.19	109.165
3	FAC	110.86	106.93	106.902	106.855	106.83
4	FASFC	110.92	107.71	107.62	107.33	107.045

Table 9. compressive strength loss of concrete mix in acid and base curing

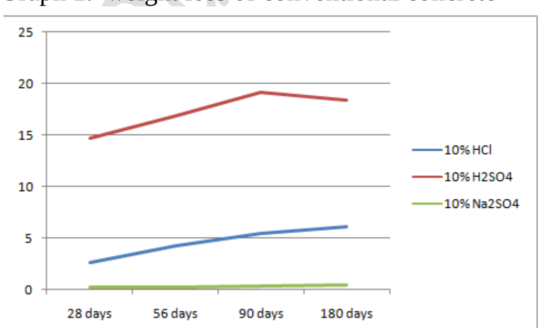
Grade of Concrete	10% HCl solution				10% Na2So4 solution				10% H2So4 solution			
	28	56	90	180	28	56	90	180	28	56	90	180
Conventional	18.34	18.69	19.12	19.45	5.24	5.29	5.34	5.4	32.50	39.79	45.38	51.13
SFC	14.77	15.08	15.43	15.93	2.41	2.46	2.49	2.51	25.3	31.86	38.39	46.69
FAC	15.83	16.23	17.11	17.83	3.51	3.57	3.61	3.68	28.34	34.64	40.13	48.89
FASFC	15.29	15.55	16.18	16.67	2.89	2.91	3.23	3.49	27.3	33.11	39.62	47.13



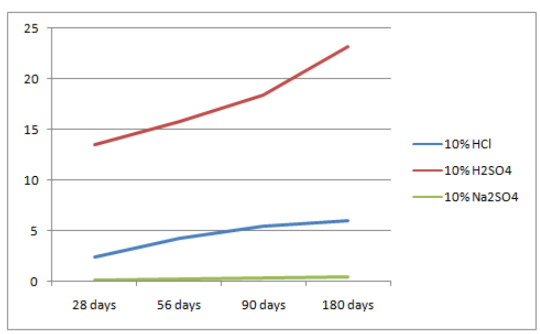
Graph 1. weight loss of conventional concrete



Graph2. weight loss of SFC



Graph3. weight loss of FAC



Graph4. weight loss in FASFC

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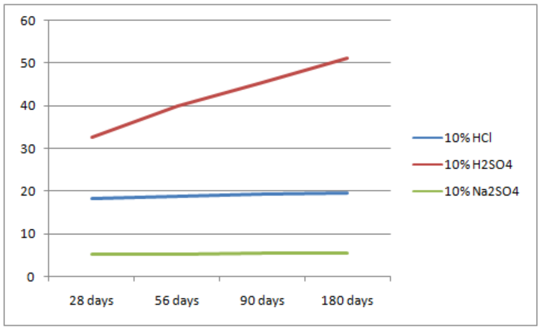
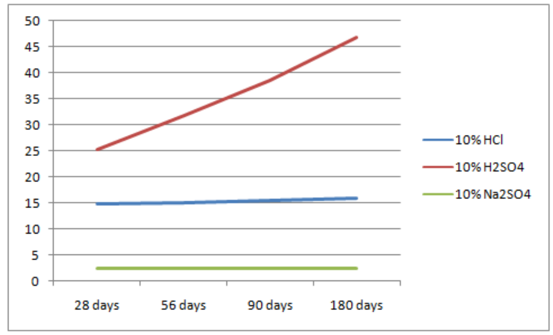
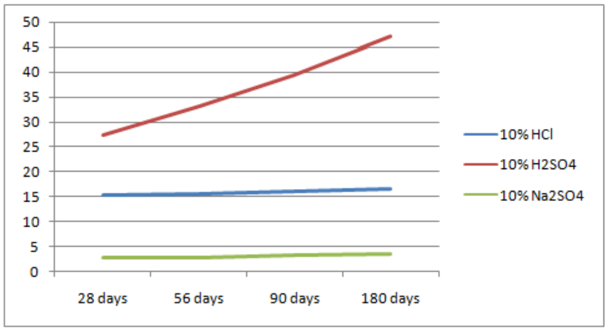


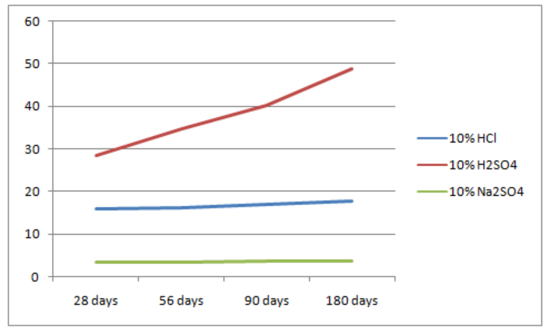
Graph 5. Compressive strength loss in conventional



Graph 6. Compressive strength loss of SFC



Graph 7. Compressive strength loss of FAC



Graph 8. Compressive strength loss of FASF

IX.CONCLUSION

In high strength concrete M100 Optimum results are come under at W/C ratio 0.25.The present study was undertaken to develop High strength concrete and investigate compressive strength of concrete specimen partial replacement of cement by fly ash and silica fume in concrete mix. The compressive strength test performed after 28 days of curing of concrete specimen.Excess amount of super-plasticizer may result in segregation of concrete and make concrete weaker.The reduction in W/C ratio increases the strength of mix. It is possible to produce mix with compressive strength of over 100MPa after 28 days.By adding silica fume as a partial replacement of cement as 0%, 5%, 10%,15%, 20%, 25% and 30%. In this upto 20% of silica fume strength is increasing gradually after 20% i.e 25%,30% we can notice decrement in strength. So optimum silica fume content is 20%.By adding Fly ash as a partial replacement of cement as 0%, 5%, 10%,15%, 20%, 25% ,30%,35% and 40%. In this upto 30% of Fly ash strength is increasing gradually after 30% i.e 35%, 40% we can notice decrement in strength. So Optimum fly ash content is 30% .Use of fly ash improves workability of concrete and bleeding is significantly reduced and other properties like cohesiveness,pumping characteristics and surface finish are improved.

Silica fume provided better stability and good flow properties than flyash. Silica fume contribute to produce high compressive strength.Fly ash did not improve the properties of concrete as significantly as silica fume due to insignificant microfilling ability and low pozzolonic activity.With these optimum contents of silica fume and fly ash made another combination of concrete i.e FASFC. But strength vales are less compared to SFC.

The combined use of silica fume and fly ash improved properties of concrete due to presence of silica fume.The amount of fly ash was not effective alone but it was used effectively with silica fume to produce high strength concrete.Acid attack on high strength concrete with and without mineral admixture is influenced by type of acid even though they may have the same concentration 10%Hydrochloric acid attack is not severe where as sulphuric acid attack is very severe and significant weight loss and compressive strength loss is recorded.The loss of weight and strength is more in case of immersing in 10% H2SO4 compared to HCL. The loss of weight and strength is very less in Na2SO4 compared Acids.

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