An Experimental Study: Effect of Aggressive Chemical Environment on Different Types of Concrete

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Abstract

The durability of concrete depends on its resistance to deterioration and the environment in which it is placed. The resistance of concrete to weathering, chemical attack, abrasion, frost and fire depends largely upon its quality and constituent material. It is generally accepted now that in designing structures the durability characteristics of the materials under consideration should be evaluated as carefully as other aspects such as mechanical properties and initial cost. A basic understanding of understanding causes of concrete deficiencies is essential to perform meaningful evaluation and successful repairs. As Concrete is more vulnerable to deterioration due to chemical or climatic attack, hence effect of aggressive chemical environment on different types of concrete is studied.
Keyword- Concrete, Durability, Chemical, Environment, Attack

I. INTRODUCTION

Every concrete structure should perform its intended functions through the expected life time of the structure, irrespective of external exposure conditions. The ability of concrete to withstand any environmental condition that may result in premature failure or severe damages is a major concern to the engineering professional. Acidic attack is one of the phenomena that may disintegrate concrete structures depending on the type and concentration of the acid. Certain acids, such as oxalic acid, are considered harmless, while weak solutions of some acids have insignificant effects. Although acids generally attack and leach away the calcium compounds of the paste, they may not readily attack certain aggregates, such as siliceous aggregates. Calcareous aggregates often react readily with acids. The high content of CaO in OPC makes it vulnerable as it is readily soluble in acid environment. Alkali activated fly ash cementitious materials (Geopolymer Concrete) are a promising alternative for the reasons that fly ash contain very less CaO. There are essentially three ways to improve concrete's resistance to acids, (1) choosing the right concrete composition to make it as impermeable as possible, (2) isolating it from the environment by using a suitable coating or (3) modifying the environment to make it less aggressive to the concrete. Acids attack concrete by dissolving both hydrated and un-hydrated cement compounds as well as calcareous aggregate. In most cases, the chemical reaction forms water-soluble calcium compounds, which are then leached away.

Concretes made of Portland cement (OPC) are highly alkaline with pH values normally above 12.5 and are not easily attacked by acidic solutions. As the pH of the solution decreases the equilibrium in the cement matrix is being disturbed and the hydrated cement compounds are essentially altered by hydrolytic decomposition which leads to the severe degradation of the technical properties of the material. At pH values lower than 12.5 portlandite is the first constituent starting dissolution. If pH decreases to values lower than stability limits of cement hydrates, then the corresponding hydrate loses calcium and decomposes to amorphous hydrogel. The final reaction products of acid attack are the corresponding calcium salts of the acid as well as hydrogels of silicium, aluminum, and ferric oxides the solubility of $Al_2O_3 \cdot aq$, and Fe_2O_3 depends on the pH value of the acting solution, while SiO_2 is insoluble in acidic solutions.

ACID ATTACK

WEAK ACIDS	**STRONG ACIDS**
• **Acetic acid**	• **Hydrochloric acid**
• **Carbonic acid**	• **Sulphuric acid**
• **Carbolic acid**	• **Sulphurous acid**
• **Lactic acid**	• **Nitric acid**
• **Phosphoric acid**	• **Hydroflouric acid**
• **Tannic Acid**	• **Hydrobromic acid**

II. EXPERIMENTAL INVESTIGATION

Criteria	Values
Specific Surface	5840 cm^2/gm
Specific gravity	2.4
Silica	58.14wt%
Alumina	28.98wt%
Ferric Oxide	4.90wt%
Calcium oxide	5.68wt%
Magnesium Oxide	1.04wt%
Sulphur Trioxide	0.64wt%
Loss of Ignition	0.54wt%
Insoluble Residue	84.44%

Table: 1 Studies on Fly Ash Concrete under Sulphate Attack

Designation	Initial Weight of Concrete Cube in kgs	Weight of cube after 7 days of curing in kgs	Percentage weight loss	Weight of cube after 28 days of curing in kgs	Percentage weight loss
A_0	8.320	8.110	2.520	7.998	3.870
A_{10}	8.285	8.100	2.232	7.988	3.584
A_{20}	8.370	8.255	1.373	8.147	2.664
A_{30}	8.230	8.175	0.668	8.020	2.511
A_{40}	8.195	8.175	0.244	8.036	1.940

Designation	28 day Compressive Strength in 5% H_2SO_4 curing N/mm^2	Percentage increase when compare to 0% fly ash concrete
A_0	20.00	0.00
A_{10}	22.20	11.1
A_{20}	24.40	22.0
A_{30}	26.20	31.0
A_{40}	21.50	7.5

A. Experimental Study

Concentrations and pH values of inorganic acids				
Acid type	0·05(M)	0·075(M)	0·100(M)	0·125(M)
Hydrochloric	1·3	1·2	1	0·9
Nitric	1·2	1·1	0·9	0·8
Sulfuric	1·2	1·0	0·9	0·8

Table: 2 the pH Values of The Aggressive Solutions.

III. RESULTS AND DISCUSSIONS

Average loss of weight of mortars in various acidic solutions within 120 days of testing period is presented in table 3. The loss of compressive strength compared to control specimens after influence of acids on properties of pozzolanic cement mortars28 days of hardening in water are presented in figure 1. The test results represent the average value of six specimens.

Average loss of weight of mortars (%)									
Concentrations (M)									
Acid Type	Exposer Time (days)	0.05		0.075		0.100		0.125	
HNO_3	30	0·75	0·70	0·60	0·63	0·60	0·63	0·60	0·63
	60	1·70	2·35	2·08	2·67	2·08	2·67	2·08	2·67
	90	2·75	3·40	3·25	3·47	3·25	3·47	3·25	3·47
	120	3·40	4·15	3·98	4·43	3·98	4·43	3·98	4·43
HCL	30	0·68	0·65	1·50	2·23	1·50	2·23	1·50	2·23
	60	1·56	1·88	2·71	3·64	2·71	3·64	2·71	3·64
	90	2·57	3·25	3·52	4·91	3·52	4·91	3·52	4·91
	120	3·28	3·94	4·91	6·23	4·91	6·23	4·91	6·23
H_2SO_4	30	0·30	0·53	0·32	0·44	0·32	0·44	0·32	0·44
	60	0·89	1·11	0·83	1·22	0·83	1·22	0·83	1·22
	90	1·42	1·89	1·48	2·07	1·48	2·07	1·48	2·07
	120	2·04	2·98	3·16	3·58	3·16	3·58	3·16	3·58

Table 3: Loss of Weight of Cement Mortars after 120 Days in Various Inorganic Acid Solutions

IV. METHODOLOGY

After testing of ingredients of concrete casting 3 sets of concrete cubes has been carried out. Concrete grade of M25 and water cement ratio of 0.45 to 0.55 was adopted. One set of 12 no of cubes were casted using ordinary Portland cement of 53 grade. Another set of 12 no of cube were casted using fly-ash based cement. Third set of 12 no of cube were casted using all above material with addition of innovative material like Polypropylene fibers. All sets are kept for the curing for the period of 30, 110, 210 and 240 days. Both sets are kept for the curing for the period of 28 days.

Fig. 1: Cube Moulding

Fig. 2: Cube Condition

V. RESULT AND DISCUSSION

Serial No.	*Grade of Concrete*	*Area Cubes cm2*	*Wt in Grams*	*Compressive Strength N/mm2*	*Testing Day*
1	*M-25*	*225*	*8570*	*26.58*	*28*
2	*M-25*	*225*	*8500*	*27.20*	*28*
3	*M-25*	*225*	*8492*	*26.67*	*28*

Table 4: Compressive Strength of Concrete with Flyash (PPC).

Inspection at the schedule interval of 28 days exposure to the acidic environment did not show any visual changes to the concrete specimens. However after exposure of 110days to 240 days of period the 0% flyash concrete has been seriously damaged and loss of compressive Strength is much more. Meanwhile the fly-ash based concrete and fiber based concrete have comparatively lesser loss of compressive strength. It is the pozolanic behaviour of the flyash that might be responsible for maintaining the compressive strength of the concrete for longer period. It can be observed that weight loss of the 0% flyash concrete were more compared to flgbash based concrete. The higher weight loss of 0% flyash concrete was mainly due to deterioration on the edges of the specimens but the high volume flyash concrete had only suffered minor surface erosion. Overall we can say flyash based concrete (with and without fibers) has shown batter performance in terms of weight loss and compressive strength over conventional concrete.

Serial No.	*Grade of Concrete*	*Area Cubes cm2*	*Wt in Grams*	*Compressive Strength N/mm2*	*Testing Day*
1	*M-25*	*225*	*8470*	*30.44*	*28*
2	*M-25*	*225*	*8520*	*30.53*	*28*
3	*M-25*	*225*	*8445*	*26.62*	*28*

Table 5: Strength of Concrete without Flyash (OPC).

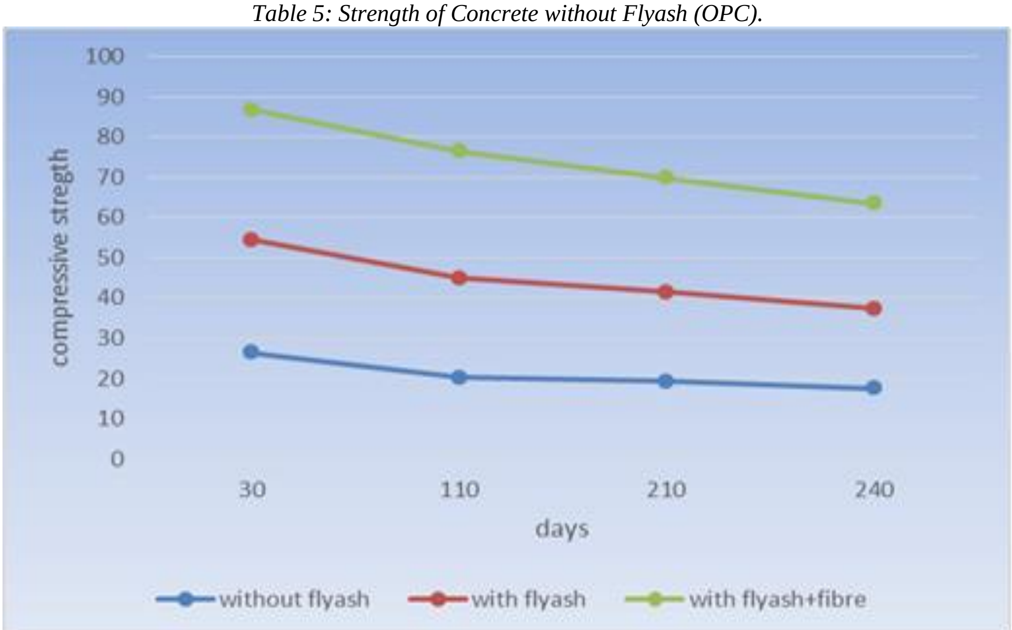

Fig. 3: Compressive Strength V/S Days of Testing

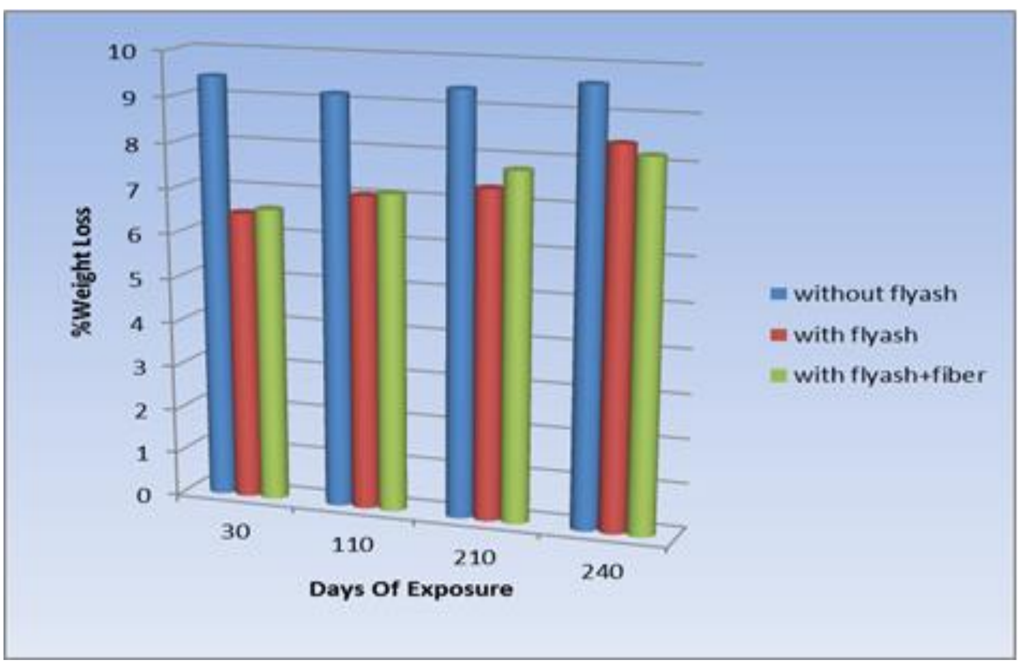

Fig. 4: Percentage Weight Loss V/S Days of Exposure

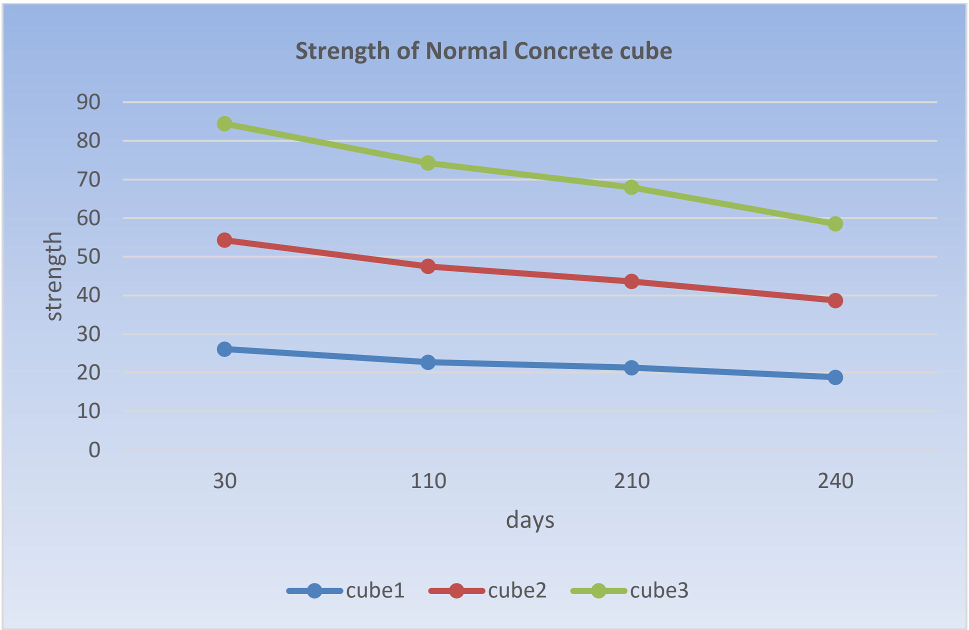

Fig. 5: Strength Graph of Normal Concrete

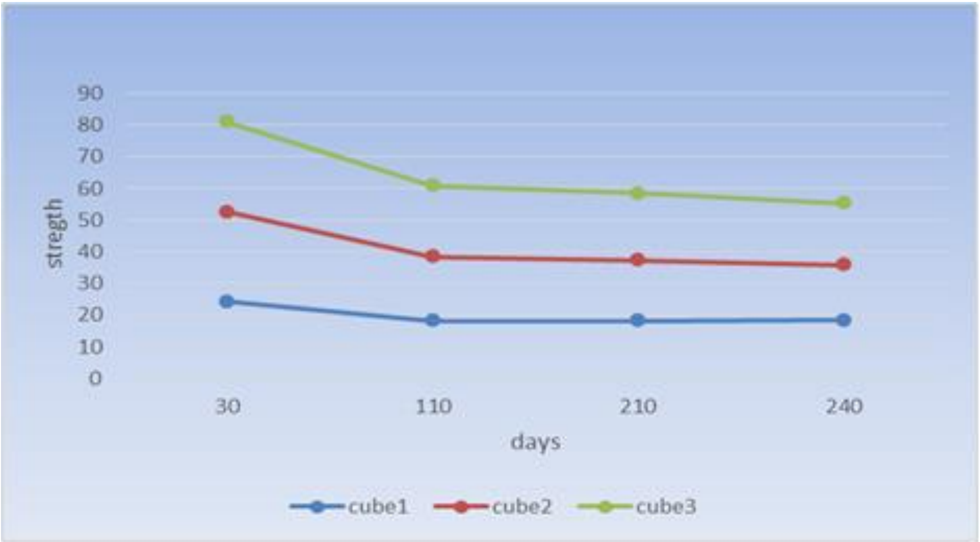

Fig. 6: Strength Graph of Flyash Based Concrete

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