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Research Paper

DURABILITY ASPECTS OF STANDARD CONCRETE

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In today's competitive environment it is becoming important to reduce the construction cost in one or other way. Nowadays OPC is widely used and it is the costly ingredient in the production of concrete. However many countries have severe shortage of cement although their requirements are vast. Pozzalonic materials are widely used in concrete and mortars for various reasons, particularly for reducing the amount of cement required for making concrete and mortar which lead to a reduction in construction cost. In the new millennium, concrete incorporating self-curing agents will represent a new trend in the concrete construction. Curing of concrete plays a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. Due to the high alkalinity of concrete it has always been susceptible to acid attack. Hence, in this investigation an attempt was made in order to know the behavior of standard concrete of M40 grade specimens curing with acids such as HCL, Alkaline such as NaOH and sulphate solution $MgSO_4$ and Na_2SO_4. In the last decade the use of Supplementary Cementing Materials (SCMs) has become an integral part of high strength and high performance concrete mix design. The addition of SCM to concrete reduces the heat of hydration and extends the service life in structures by improving both long term durability and strength. Some of the commonly used SCMs are Flyash, Silica fume and Metakaoline. This paper presents results of the durability characteristic properties of M_{40} grade of with and without SCMs.

Keywords: Standard concrete, Acid attack, Alkaline attack, Supplementary Cementing Materials (SCMs), Durability

INTRODUCTION

Another advantage of using SCMs is increase in durability of concrete which consequently results increase in resource use efficiency of ingredients of concrete which are depleting at very fast rate. Long term performance of

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structure has become vital to the economies of all nations. The use of fly ash and silica fume is becoming more common because they improve concrete durability and strength, especially where high early age curing temperatures occur. High replacement levels of fly ash are uncommon however, because of resistance to change by the cement industry and because of concerns about the early-age strength and the quality of concretes produced with high cement replacement levels.

Kevin Smith *et al.* (2004) established a testing regime to optimize the strengths and durability characteristics of a wide range of high-performance concrete mixes. The intent of the selected designs was to present multiple solutions for creating a highly durable and effective structural material that would be implemented on Pennsylvania bridge decks, with a life expectancy of 75 to 100 years. One of the prime methods of optimizing the mixtures was to implement supplemental cementitious materials, at their most advantageous levels. Fly ash, slag cement, and microsilica all proved to be highly effective in creating more durable concrete design mixtures.

The chemical resistance of the concretes was studied through chemical attack by immersing them in an acid solution. After 90 days period of curing the specimens were removed from the curing tank and their surfaces were cleaned with a soft nylon brush to remove weak reaction products and loose materials from the specimen. The initial weights were measured and the specimens were identified with numbered plastic tokens that were tied around them. The specimens were immersed in 3% H_2SO_4 solution and the pH (4) was maintained constant throughout. The solution was replaced at regular intervals to maintain constant concentration throughout the test period. The mass of specimens were measured at regular intervals up to 90 days, and the mass losses were determined (Dinakar *et al.*, 2008).

An experimental study on the effect of fly ash and silica fume on the properties of concrete subjected to acidic attack and sulphate attack. Changes in physical and chemical properties in the mortars with different replacements by fly ash and silica fume when immersed in 2% H_2SO_4, 10% Na_2SO_4 and 10% $MgSO_4$ solutions for 3 years were investigated (Kazuyuki Torii and Mitsunori Kawamura, 1994).

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 (Wee *et al.*, 2000).

MATERIALS USED IN THE PRESENT STUDY

Cement

Ordinary Portland cement Zuari-53 grade conforming to IS: 12269 (1987) were used in concrete. The physical properties of the cement were listed in Table 1.

Table 1: Physical Properties of Zuari-53 Grade Cement

S. No.	1	2	3	4	5		
Properties	Specific Gravity	Normal Consistency	Initial Setting time	Final Setting time	Compressive Strength (Mpa)		
					3 days	7 days	28days
Values	3.15	32%	60 min	320 min	29.4	44.8	56.5

Aggregates

A crushed granite rock with a maximum size of 20mm and 12mm with specific gravity of 2.60 was used as a coarse aggregate. Natural sand from Swarnamukhi River in Srikalahasti with specific gravity of 2.60 was used as fine aggregate conforming to zone- II of IS 383 (1970). The individual aggregates were blended to get the desired combined grading.

Water

Potable water was used for mixing and curing of concrete cubes.

Supplementary Cementing Materials

Flyash

Fly ash was obtained directly from the M/s Ennore Thermal Power Station, Tamilnadu, India. The physicochemical analysis of sample was presented in Table 2.

Silica Fume

The silica fume used in the experimentation was obtained from Elkem Laboratory, Navi Mumbai. The chemical composition of Silica Fume was shown in Table 3.

Metakaoline

The Metakaoline was obtained from M/s. 20 Microns Limited, Baroda, India. The chemical composition of Metakaoline was shown in Table 4.

Super Plasticizer

VARAPLAST SP123 is a chloride free, Superplasticising admixture based on selected synthetic polymers. It is supplied as a brown solution which is instantly dispersible in water and also it can provide very high level of water reduction and hence major increase in strength can be obtained coupled with good retention of workability to aid placement.

RESULTS AND DISCUSSION

In the present work, the mix proportion for HSC mix of M50 was carried out according to IS:10262 (2009) recommendations. The mix

Table 2: Physicochemical Properties of Flyash Sample

Sample	Specific Gravity	Specific Surface area (m^2/g)	Moisture Content (%)	Wet Density (g/cc)	Turbidity (NTU)	pH	
Flyash	2.20	1.24	0.20	1.75	459	7.3	
	Chemical Composition, Elements (weight %)						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	TiO_2	Na_2O_3	MgO
	56.77	31.83	2.82	0.78	1.96	2.77	0.68	2.39

Table 3: Chemical Composition of Silica Fume

Chemical Composition	Silica (SiO_2)	Alumina (Al_2O_3)	Iron Oxide (Fe_2O_3)	Alkalies as ($Na_2O + K_2O$)	Calcium Oxide (CaO)	Magnesium Oxide (MgO)
Percentage	89.00	0.50	2.50	1.20	0.50	0.60

Table 4: Chemical Composition of Metakaoline

Chemical Composition	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	SO_3	Na_2O	K_2O	LOI
Mass Percentage (%)	52 to 54%	42 to 44%	<1 to 1.4%	<3.0%	0.1%	<0.1%	<0.1%	<0.05%	<0.4%	<1.0%

proportions were presented in Tables 6. The tests were carried out as per IS: 516-1959. The 150 mm cube specimens of various concrete mixtures were cast to test compressive strength. The cube specimens after de-moulding were stored in curing tanks and on removal of cubes from water the compressive strength were conducted at 7 days, 28 days and 90 days. The test results were compared with individual percentage replacements (Binary System) and combinations of admixtures (Ternary System) for M_{40} Mix.

Acid Attack Test

The concrete cube specimens of various concrete mixtures of size 150 mm were cast and after 28 days of water curing, the specimens were removed from the curing tank and allowed to dry for one day. The weights of concrete cube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 90 days after 28 days of curing. Hydrochloric acid (HCL) with pH of about 2 at 5% weight of water was added to water in which the concrete cubes were stored. The pH was maintained throughout the period of 90 days. After 90 days of immersion, the concrete cubes were taken out of acid water. Then, the specimens were tested for compressive strength. The resistance of concrete to acid attack was found by the % loss of weight of specimen and the % loss of compressive strength on immersing concrete cubes in acid water. Figure 1 represents the Percentage loss

Table 6: Mix Proportion for M_{40} Concrete

	Cement	Fine aggregate	Coarse aggregate (20 mm 20% and 12.5 mm 80%)	Water	Secondary Cementing Materials	Super plasticizer
Composition in kg/m^3	270	862	1097	140	115	7.7
Ratio in %	1	3.193	4.062	0.518	0.425	0.0285

in Weight of M_{40} due to Acidity respectively. Figure 2 represents the Percentage loss in Strength of M_{40} due to Acidity respectively.

Figure 1: Percentage Loss in Weight of M_{40} Due to Acidity

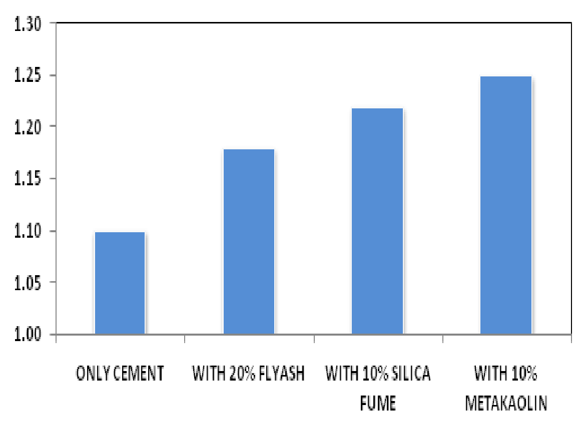
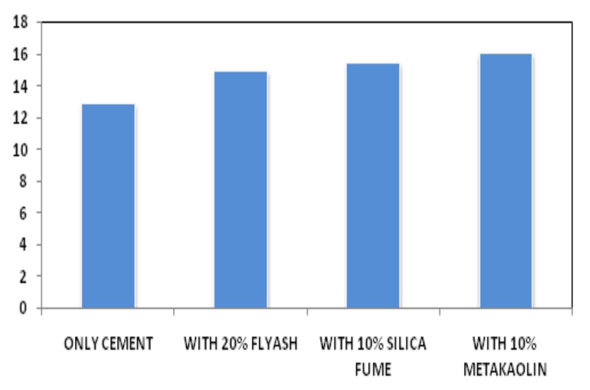


Figure 2: Percentage Loss in Strength of M_{40} Due to Acidity



Alkaline Attack Test

To determine the resistance of various concrete mixtures to alkaline attack, the residual compressive strength of concrete mixtures of cubes immersed in alkaline water having 5% of sodium hydroxide (NaOH) by weight of water was found. The concrete cubes which were cured in water for 28 days were removed from the curing tank and allowed to dry for one day. The weights of concrete cube specimen were taken. Then the cubes were immersed in alkaline water continuously for 90 days. The alkalinity of water was maintained same throughout the test period. After 90 days of immersion, the concrete cubes were taken out of alkaline water. Then, the specimens were tested for compressive strength. The resistance of concrete to alkaline attack was found by the % loss of weight of specimen and the % loss of compressive strength on immersion of concrete cubes in alkaline water. Figure 3 represents the Percentage loss in Weight of M_{40} due to Alkalinity respectively. Figure 4 represents the Percentage loss in Strength of M_{40} due to Alkalinity respectively.

Figure 3: Percentage Loss in Weight of M_{40} Due to Alkalinity

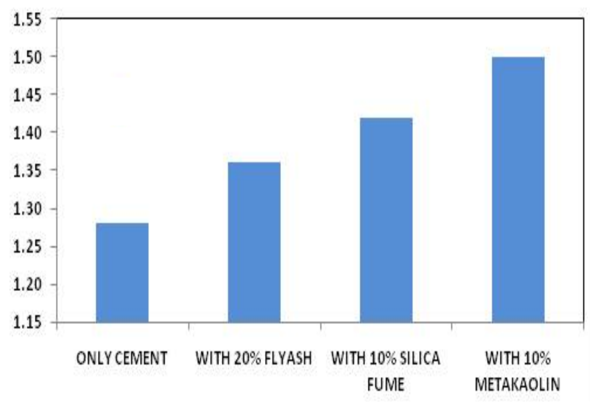
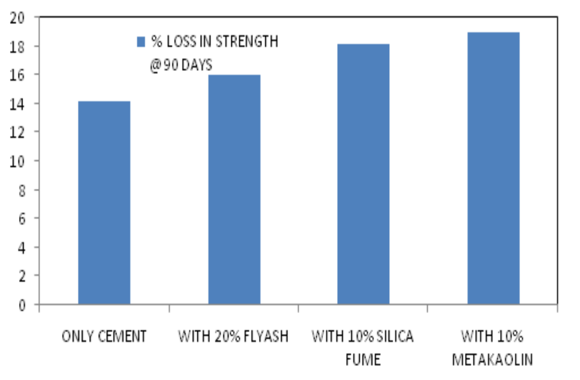


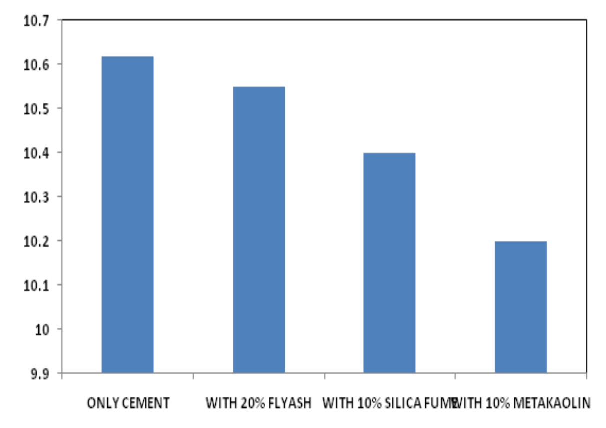
Figure 4: Percentage Loss in Strength of M_{40} Due to Alkalinity



Sulphate Attack Test

The resistance of concrete to sulphate attacks was studied by determining the loss of compressive strength or variation in compressive strength of concrete cubes immersed in sulphate water having 5% of sodium sulphate (Na_2SO_4) and 5% of magnesium sulphate ($MgSO_4$) by weight of water and those which are not immersed in sulphate water. The concrete cubes of 150mm size after 28days of water curing and dried for one day were immersed in 5% Na_2SO_4 and 5% $MgSO_4$ added water for 90days. The concentration of sulphate water was maintained throughout the period. After 90days immersion period, the concrete cubes were removed from the sulphate waters and after wiping out the water and girt from the surface of cubes tested for compressive strength following the procedure prescribed in IS: 516-1959. This type of accelerated test of finding out the loss of compressive strength for assessing sulphate resistance of concrete Mehta and Burrows (2001). Figure 5 represents the Percentage loss in strength of M_{40} due to Sulphate respectively.

Figure 5: Percentage Loss in Strength of M_{40} Without Admixture Due to Sulphate



CONCLUSION

1. In M_{40} grade concrete as the water-cement ratios of 0.518 was insufficient to provide the good workability; hence super plasticizer was necessary for M_{40} mix.
2. It is observed from the results the maximum percentage loss in weight and percentage reduction in compressive strength due to Acids for M_{40} grade concrete are 1.25%, 16% with replacement of 10% Metakaoline and the minimum percentage loss in weight and strength are 1.18%, 14.9% with replacement of 20% Flyash. There is considerable variation in loss of weight and strength only with Silica Fume replacement.
3. Present investigation shows that the maximum percentage loss in weight and percentage reduction in compressive strength due to Alkalinity for M_{40} grade concrete are 1.5%, 19% with replacement of 10% Metakaoline and the minimum percentage loss in weight and strength are 1.36%, 16% with replacement 20% Flyash. There is considerable variation in loss of weight and strength only with Silica Fume replacement.
4. It is identified that the maximum percentage reduction in compressive strength due to Sulphates of M_{40} grade concrete is 10.55% with replacement 20% Flyash and the minimum percentage reduction in strength is 10.2% with 10% Metakaoline.

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