Enhancing High Performance Concrete with Pozzolanic Material

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Abstract: Manufacturing of high performance concrete, which is majorly used as building material in the major and huge infrastructure projects, is a daunting task. Though the recent advancements have conquered the hurdles of the preparation of high performance concrete, the use of green materials such as Fly Ash and Rice Husk Ash is limited. Apart from the green materials, many conventional and mineral admixtures or micro materials are available in the market, which enhances the quality and performance of concrete such as Metakaoline, Alccofine and Silica Fume etc.
The quality of concrete mix is assessed through various mechanical properties like compressive strength, flexural strength and split tensile strength and various durability tests like rapid chloride penetration test (RCPT), sorptivity test, chloride resistance test, accelerated corrosion test and sea water attack test are carried out to analyses the performance of HPC.
The objective of this study is to evaluate the structural strength of high performance concrete by utilizing green and Pozzolanic material as supplementary cementitious material and potential use of non-destructive testing devices for in-situ strength parameters of HPC during and after construction. About 100 concrete specimens of different for different mix proportions were analyzed in the study.
This study helps in identifying influence of Alccofine, Fly Ash, Rice Husk ash, Fly Ash on strength characteristics of HPC. The use of alternative material of Portland cement leads to reduction of emission gases and impact on production capacity of cement plant. This study also provides a strategy to reducing the cost of waste disposal and its related gains. This research work will enhance and accelerates the decision making process in the pre, during and post construction phases of any infrastructure projects.

Key_Words: High Performance Concrete, Supplementary Cementitious Material, Waste Utilization, Health Analysis of Concrete, Nondestructive Testing of Concrete, Mechanical Properties, Durability .

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1. Introduction-

1.1. High Performance Concrete:

In recent years, the terminology "High-Performance Concrete" has been introduced into the construction industry. The American Concrete Institute (ACI) defines high-performance concrete as concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely when using conventional constituents and normal mixing, placing and curing practices. A structure commentary to the definition states that a high-performance concrete is one in which certain characteristics are developed for a particular application and environment. Examples of characteristics that may be considered critical for an application are(Stark2012[1]
Because many characteristics of high-performance concrete are interrelated, a change in one usually occurred because of the interrelation between the three characteristics.
The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry([Swami&asli 2011]
Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material(. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact.[(Plamer2010])

2. Materials and Methods.-This research consists of tests for the mechanical strength and also the test for the durability of concrete. The different tests for the mechanical strength are
1. Compressive strength test.
2. Split tensile test
3. Flextural strength test

2.1. Compressive Strength test------ The compressive strength for the different Concretes is given in Table 4 and depicted in Fig1. In general, all standard moist cured concrete mixtures gained. The compressive strength of the concrete is the most common type of test set by the Engineers to test the performances. The compressive strength of concrete is measured by breaking the cylindrical specimen of concrete in compression testing machine. The compressive strength is measured by dividing the failure load by the area of cross section[(PerenchioKaufran2008)]

Table:1 compressive strength test result

Age, days						
	M-1		M-2		M-3	
	Moist cured	VTCE	Moist cured	VTCE	Moist cured	VTCE
3	53	48	57	58	64	66
7	54	58	69	75	73	86
28	73	73	87	88	99	100
56	73	78	93	92	105	101
91	82	83	99	100	104	130
182	79	71	94	88	81	73
365	78	69	91	77	94	81

2.2 Splitting Tensile Strength Specimen compressive Strength Test Result Concrete cylinder specimens of diameter 100mm and 200mm length were cast for testing in the age of 28, days in compliance with BS 1881: part 117:1983. Table-6 shows the result of splitting tensile strength of 28 days per each mix. The mixed groups that are (H) and (I) supply the low value of the final result in comparison with the other mixes swany and a-asali. The 5% of silica fume record high result as **.**Variation of Compressive strength %. MPa while 30% of fly ash shows ([Dammy2007])

2.2.1 Splitting Procedure:

2.2.1.1 Marking: Draw diametric lines on each end of the specimen using a suitable device that will ensure that they are in the same axial plane (see Fig. 1, Fig. 2 and Note 2), or as an alternative, use the aligning jig shown in Fig. 3 (Note 3).The device consists of three parts as follows:

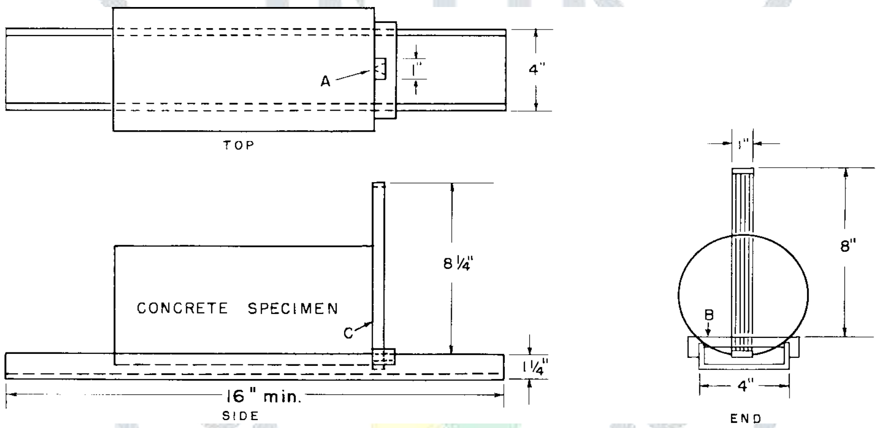

Fig1 :Split tensile measurement procedure

1. A length of 4-in. (100-mm) steel channel, the flanges of which have been machined flat,
2. A section of a tee bar, *B*, that is grooved to fit smoothly over the flanges of the channel and that includes a rectangular notch for positioning the vertical member of the tee bar assembly, and (Plamer 2010)A vertical bar, *C*, containing a longitudinal aperture (cleft), *A*, for guiding a pencil[Frigg2007]

The tee bar assembly is not fastened to the channel and is positioned at either end of the channel without disturbing the position of the specimen when marking the diametric lines.A base for holding the lower bearing strip and cylinder[Stark2006]),

A supplementary bearing bar conforming to the

2.3 Split tensile strength test result.

The Split tensile strength of different mix were tested and noted as per the table below.

Table.2. Mechanical test: Split tensile strength test

Code mix	Density KN/m^3	Splitting strength MPa
A	2.41	3.85
B	2.34	4.56
C	2.29	4.65
D	2.32	5.10
E	2.25	4.80
F	2.38	3.82
G	2.39	3.78
H	2.32	3.49
I	2.31	3.60

3.3 . Flexure strength test-

3.3.1 Introduction- The flexure test is a test under the combined load tensile, compressive and the shear acting on a sample specimen. This mechanical testing method measures the behavior of materials subjected to simple bending **load**s. Like tensile modulus, flexural modulus (stiffness) is calculated from the slope of the bending load vs. deflection curve([Poole1998]). Flexural testing involves the bending of a material, rather than pushing or pulling, to determine the relationship between bending stress and deflection. Flexural testing is commonly used on brittle materials such as ceramics, stone, masonry.

3.3.2 CALCULATION of Flexture strength.

The Flexural Strength or modulus of rupture (**f_b**) is given by

f_b= pl/bd^2 whena> 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen) or

f_b= 3pa/bd^2 whena< 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen b = width of specimen (cm) d = failure point depth (cm) l = supported length (cm) p = max. Load (kg)

3.3.3 Flexure test result.

All the specimen was tested in the flexure testing machine. The result was noted in terms of modulus of rupture which is a measure of flexural strength. The record of the result was maintained and the result was critically analyzed [Helmut2005]

Table 3: Mix proportioning of Flexure strength test

Code mix		Binder content Kg/m^3			WATER	
	OPC	FLY ASH	SILICA FUME	MIRHA	W/C	W (Kg/m^3)
A	600	0	0	0	0.33	200
B	540	60	0	0	0.37	200
C	420	180	0	0	0.46	192
D	570	0	30	0	0.35	200
E	540	0	60	0	0.36	192
F	540	0	0	60	0.39	209
G	510	0	0	90	0.41	209
H	360	180	60	0	0.56	200
I	360	180	0	60	0.56	200

Table4.Flexture test result

Code Mix	**Density KN/m^3**	**Flexural strength MPa**
A	2.41	8.64
B	2.34	9.35
C	2.29	8.43
D	2.32	10.12
E	2.25	7.68
F	2.38	9.79
G	2.39	7.59
H	2.32	6.76
I	2.31	8.25

3.3.4Flexure test result remark

Table-6 shows the result of flexural strength test which was conduct on the beam of size (100*100*500) mm^3 according to the BS 1881: part 118:1983. The 5% of the SF own highest value as 10.12 Mpa while the 10% of MIRHA also record high value as 9.79 Mpa compared with the control mix.

4.1 Measurement of Chloride Content in concrete

To measure chloride content in concrete, samples of concrete powder were taken from the specimen by drill at 100 mm, 200 mm, and 400 mm from the exposed surface. Chloride content in concrete was measured by a chloride ion meter[Stark2009]. The procedure for measurement is discussed below Water- and acid-soluble chloride concentrations in concrete made with different cements are shown in . I cant difference of chloride concentration profile is observed for SCB and AL compared with the others. In the case of AL, a higher chloride concentration is observed at the surface region of the specimen, but it quickly drops with distance inside the specimen.For SCB, the peak chloride concentration is observed near the surface region and it drops with distance inside the specimens([Fig2006]).

Table5 – Chloride-ion permeability of concrete mixtures

Age, days	Average Charged Passed, Coulombs		
	M-1	M-2	M-3

	Moist cured	VTCE	Moist cured	VTCE	Moist cured	VTCE
28	4360	3170	690	190	240	105
60	2060	1740	330	170	180	65
91	1895	1830	300	215	150	200

Table 6 **Chloride-ion permeability of concrete (ASTM C 1202)**

Charged Passed, Coulombs	Chloride Permeability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible

4.2 Wind Tunnel Method of measurement

4.1.1 Introduction:

Resistance to Chloride-Ion Penetration The chloride ingress is measured by non-destructive techniques which are based upon three methods: Electrical resistivity, Ion selective electrode (ISE) and optical fiber sensor.

4.1.1.2 Specimen Size-

Concrete specimens whose size is 100 x 100 x 150 mm were used. Two types of concrete mix whose water cement ratio is 40% and 60% were used, . Specimens were cured in water for 28 days. However, concrete strength was not measured. After curing, five surfaces of each specimen except one exposed surface were coated

The outline of the wind tunnel, in which coastal environment involving airborne salt is simulated. This shows the overview of the wind tunnel. The size of the cross section inside of the wind tunnel is 1 m x 1 m. The length of wind path is about 12 m in one round. Particles of salt water are produced by putting fine air bubbles into the salt water unit (Fig. 2(b)) and blown by the fan (Fig. 2(a)). Concrete specimens are set in both the first and the second floor and exposed to wind involving airborne salt (Fig. 2(c)). Wind velocity and amount of airborne salt at installation position of each specimen in the wind tunnel were measured prior to the exposure test. Wind velocity was measured by a portable wind velocity meter. The measured wind velocity in the tunnel was 1.5 m/s in average. The amount of airborne salt at each specimen's position was measured by a gauze specimen whose size is 100 mm x 100 mm (Fig. 2(d)). Gauze specimens are exposed at the testing position for four hours to catch airborne salt.

Measurement data on initial chloride content in concrete before the exposure, the average chloride content on 12 days were used as initial chloride content. Hence, adjusted chloride ingress into concrete at each exposure time was calculated by drawing the initial value from the measured absolute chloride content. Chloride content in concrete during exposure increased with increasing of the intensity of airborne salt Increasing of chloride content near the surface is greater than those in the deeper portion It is regarded that chloride ingress into concrete is affected by the intensity of airborne salt. Comparing specimens made of same concrete mixture, chloride ingress is accelerated by the intensity of airborne salt to which the specimen is continuously exposed. Part of the airborne salt which reached the surface of concrete was caught and gradually penetrated into concrete by diffusion mechanism. It is supposed that the amount of airborne salt caught by concrete surface is dependent of the intensity of airborne salt.

The chloride level at 75 mm depth, however, is higher for SCB compared with the AL. For OPC, HES, and MH, the chloride distribution pattern is almost same. For these cases, a lower chloride concentration is observed at the surface region and rises to a constant value at the inner region. For OPC, HES, and MH, the chloride concentration at a cover depth of 75 mm is 10 times higher than the chloride concentration at a cover depth of 75 mm for SCB and AL. Based on the microstructural investigation,5 it was found that the outer region became denser compared with the inner region for SCB and AL, and the improvement was significant for AL. The data strongly suggest that the denser microstructure of SCB and AL, as well as the improvement of microstructure at the outer region of the specimen with the on-going exposure in marine environment, reduces chloride ingress in concrete.[(Landgreen and Halidey1986)]

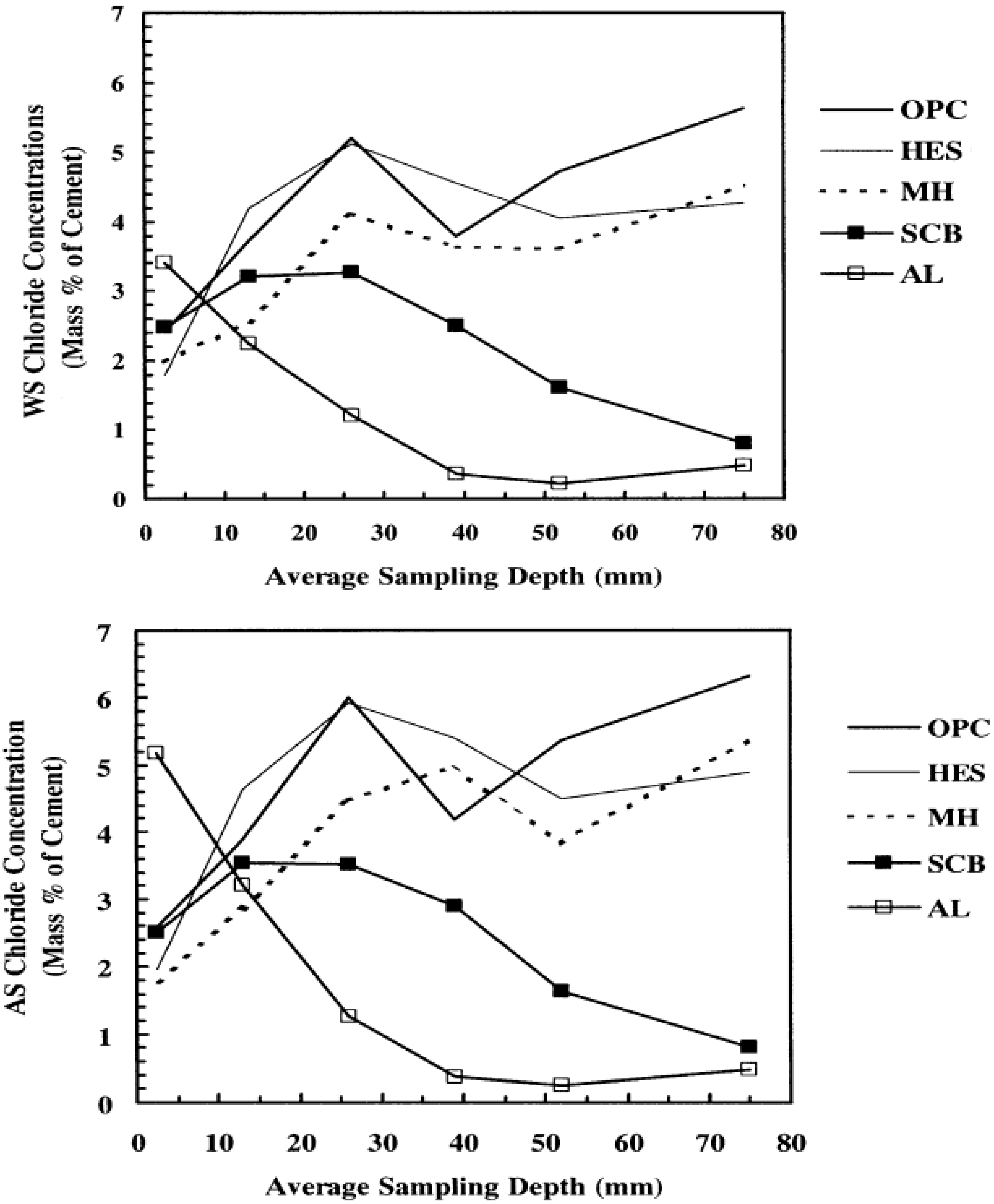

Fig2:Chloride Concentration vs sampling depth

A similar result was also observed for SCB after 15 years of marine tidal exposure.1 These results indicate that use of SCB or AL is very effective limiting the chloride ingress in concrete. AL showed reduction in compressive strength.

5. Sulfate Resistance Test

Determining changes in length of specimens, dynamic modulus, and pulse velocity for the specimen under consideration. Fig. 2 through Fig. 9 present the effect of sulfate attack on the specimens from all mixtures of HPC. The specimens were immersed in 10% sulfate solution for the study of sulfate attack on HPC.

The length change data are depicted in Fig. 2 for Mixture M-1, Fig. 3 for Mixture M-2, and Fig. 4 for Mixture M-3, respectively. Generally, VTCE-cured specimens exhibited higher length change than moist-cured specimens. However, the length changes for all the concrete mixtures revealed insignificant effect of sulfate attack on all HPC mixtures cured in both curing environments.

Fig. 5 and Fig. 6 depicts changes in the dynamic modulus for HPC Mixtures M-1 and M-2, respectively. The results indicate the increase in dynamic modulus of concrete with age when exposed to sulfate solution. The difference in dynamic modulus values of VTCE-cured and moistcured concrete specimens for concrete Mixture M1 is insignificant. However, it is significant for Mixture M-2. Addition of silica fume probably is responsible for this improvement. (AASHTO T299 1986)

The changes in pulse velocity values for Mixture M-1 through M-3 are given in Fig. 7 to 9, respectively. Fig. 7 shows that up to 15 weeks of age the changes in pulse velocity for both VTCE and moist-cured concrete Mixture M-1 was significant which reduced at the later age. For Mixture M-1, moist-cured specimens had higher change in pulse velocity than VTCE-cured concrete. A reverse trend is visible in Fig. 8 and

Fig. 9 for concrete Mixture M-2 and M-3. However, the differences in change in pulse velocity for concrete cured by both modes of curing seldom exceeded 10%. This indicates that simulated summer weather concreting does not have significant effect on the resistance to sulfate attack of the HPC mixtures under study.

6 Air water permeability test.

6.1 Permeability Test

The permeability of concrete at the surface is a major factor in determining thedurability of concrete structures. A reliable **permeability test** of the concrete over is therefore crucial – not only in the laboratory but als

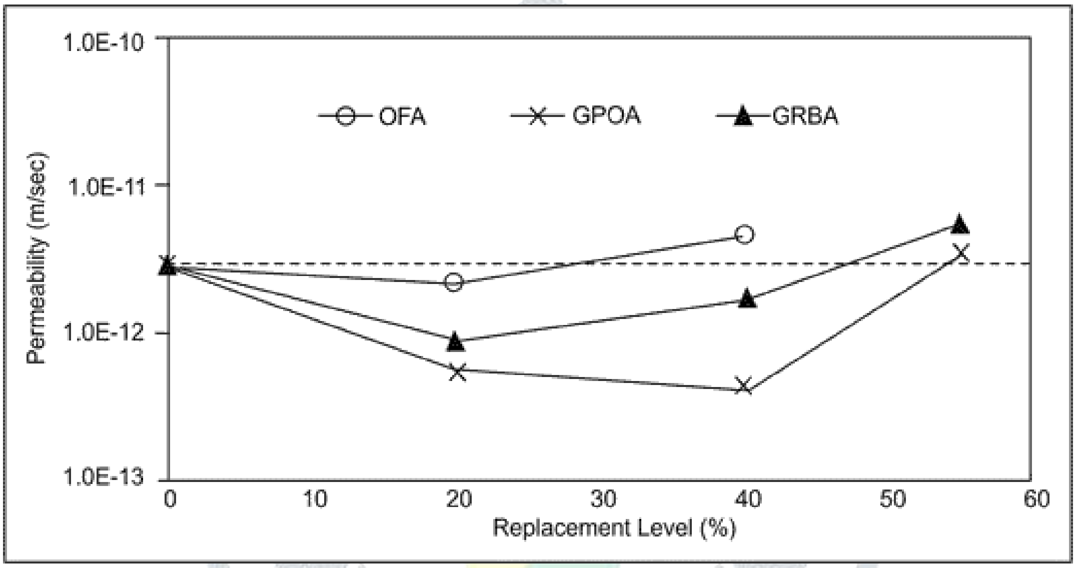

Fig3:Water permeability &percentage replacement.

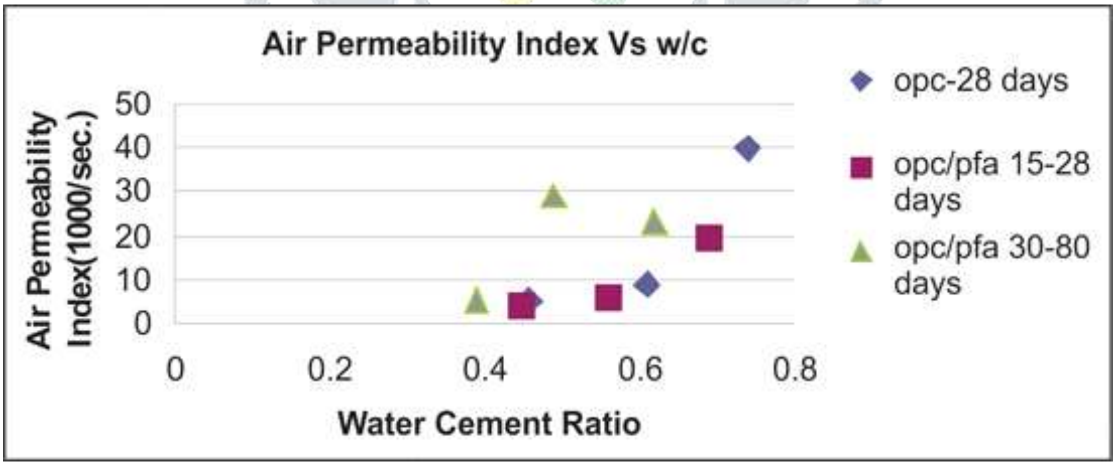

Fig4:PermeablevoidsVsCompressive strength

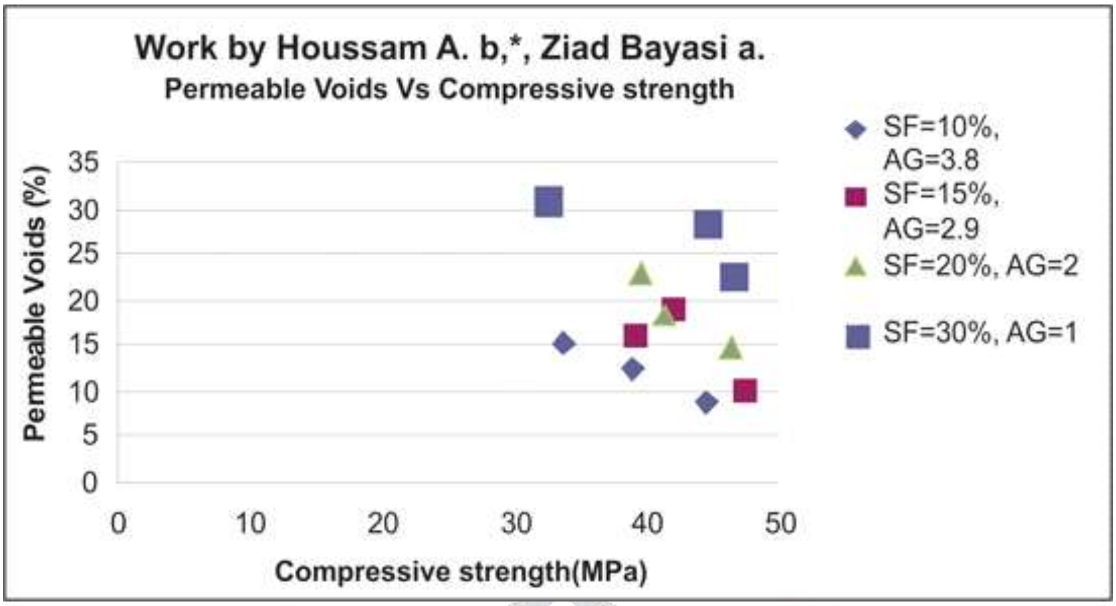

Fig5 Concrete Permeability Testing for corrosion of reinforcement

The concrete bridges having chloride-induced corrosion of reinforcement has long been the major durability problem and tests developed have attempted to measure, directly or indirectly, the penetrability of chloride ions into concrete. Such tests include the salt ponding methods of AASHTO T 259 and ASTM C1543 and the electrical methods of AASHTO T 277, AASHTO TP 64, and ASTM

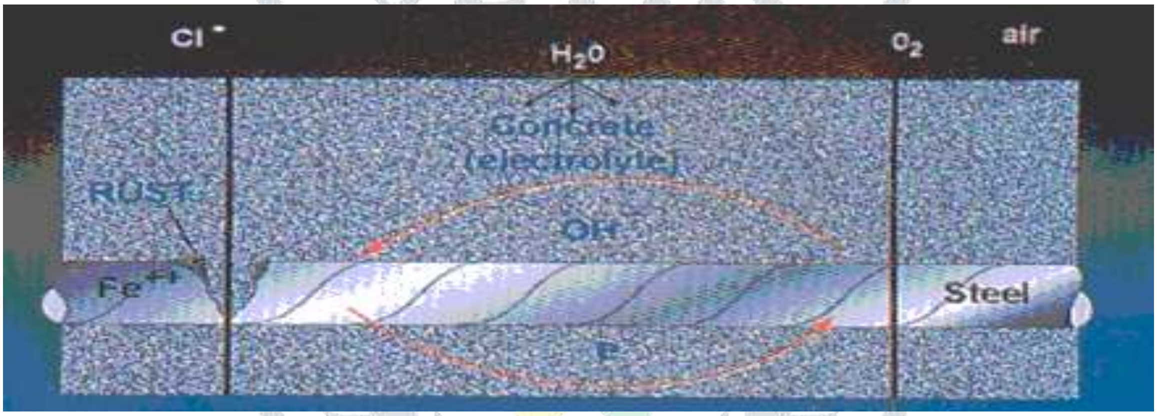

Fig 6:Corrosion mechnism in reinforcement.

C1202 for rapid assessment of concrete's resistance to chloride ion penetration. Of these, the electrical resistance tests of AASHTO T 277 and ASTM C1202 have gained the widest use and are often found in specifications for concrete materials when chloride-induced corrosion is a concern. With the advent of service-life prediction models, an emphasis has been placed on methods that measure the more fundamental properties of concrete such as chloride diffusion (ASTM C1556) and water Absorptivity (ASTM C1585). This article will describe and discuss the ponding and electrical tests. A future article will focus on the diffusion and Absorptive tests. AASHTO T 259 and ASTM C1543 were designed to simulate the mechanism by which chloride ions penetrate into concrete bridge decks. The test specimens consist of a concrete slab with a minimum thickness and a minimum surface area. A dike is constructed around the top perimeter to hold the ponding solution. The slabs are typically moist cured for a length of time followed by a period of drying at 50% relative humidity before ponding with a 3% sodium chloride solution. AASHTO T 259 calls for 14 days moist curing followed by 28 days of drying, while ASTM C1543 specifies moist curing either until a specified strength is reached or 14 days, followed by 14 days of drying. Prior to ponding, the sides of ASTM C1543 slabs are sealed to prevent evaporation from those surfaces and impose directional control of the chloride penetration. The ponded slabs are stored to allow air circulation around the slabs in a room at 50% relative humidity. A cover is placed over the solution pond to prevent evaporation of water from the solution. AASHTO T 259 calls for a ponding period of 90 days([Power1985]). For low-permeability concretes, this is typically found to be too short for significant penetration of chloride ions into the concrete, and ponding is often extended for longer periods. For this reason, ASTM C1543 allows the user to select the ponding

7. Conclusions and Result discussion.

1.High Performance Concrete can be prepared to give optimized performance characteristics for a given loading and exposure conditions along with the requirements of cost, service life and durability.

2.The applications of concrete will necessitate the use of High Performance Concrete incorporating new generation chemical admixtures (PCE based superplasticizers) and available mineral admixtures.

3.The success of High Performance Concrete requires more attention on proper Mix Design, Production, Placing and Curing of Concrete. For each of these operations controlling parameters should be achieved by concrete producer for an environment that a structure has to face. (Power 2012)

4. In my research paper after comprehensive result comparison of different experts and through review of my experimental work concluded at the point that the optimization of mineral admixture astriumph in my career and it would be not possible flyash, silica fume, ground glass blast furnace slag, metakaolin depends on loading condition, Type and nature of exposure severity and also the chemical admixture used.
5.My research paper gives special focus of enhancement of concrete by pozzolanic material as siilica fume which is 10% as optimization .This pozzolanic material has the maximum enhancement at 10% in comparison to binary mixes ane tertiary mixes of other pozzolanic materials.

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