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An Experimental Investigation for the Permeability of Chloride in Admixtured Cement Mortars using Rapid Chloride Permeability Test Apparatus

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***Abstract*— Contemporary cement and concrete industries are facing the shortage of traditional good quality raw materials and ingredients. Certain industries, on the other hand, are producing unmanageable amounts of waste products as by-products. A variety of these materials have been successfully utilized as mineral admixtures which have been successfully proved as mineral admixtures in cement and concrete. Though, huge volume of mineral admixtures have been discharging from these industries, considerable amounts of these mineral admixtures are yet to be utilized as ingredients for cement,admixtures. Hence,an investigation was carried out to utilize these by-products as mineral admixtures in cement concrete works. The investigation proved good performance of cement concrete made with the mineral admixtures is found to be effective when they are used in conjunction with super plasticizers. However, the information available on the performance of super plasticizers in cement concrete made with mineral admixtures is very limited, particularly on the durability of cement concrete. Most of the investigations in this report are focussed on permeability of concrete.**

In the present study we had cement mortar cylinders of 5%, 10%, 15% were casted by replacement of cement with mineral admixtures such as Silica Fume, Ground Granulated Blast Furnace Slag, Fly Ash, Rice Husk Ash and Chemical Admixture such as Super Plasticizer. The method adopted in the investigation used is of as per the code specifications of ASTMC1202-05 and A Standard Equipment of Rapid Chloride Test Apparatus for the determination of permeability of chloride.

From the test results, it can be concluded that permeability of cement when mixed with silica fume is less when compared with other admixtures. However, there is a considerable decrease in permeability when chemical admixtures are used along with mineral admixtures.

Keywords*— *Cement Mortar, Permeability, Chloride e.t.c

INTRODUCTION

1. The greatest challenge before the construction industry is to serve the two pressing needs of human society namely the protection of the environment and meeting the infrastructure requirement of our growing pollution and consequential needs of industrialization and urbanization in the past. The concrete industry has met these needs to well. However for a variety of reasons, the situation has been changed now.
2. The cement and concrete industries due to their large size are unquestionably feasible scope for economic and safe disposal of millions of tonnes of industrial by products such as fly ash, silica fume, slag, rice husk ash. Due to their properties, by products can be used in certain amount such as cement replacement material than in the practice today. Therefore, it should be obvious that certain scale cement replacement with industrial by products is highly advantageous from the sand point of cost, economy, energy efficiency, durability and overall ecological and environmental benefits.
3. The advantageous in concrete technology method of construction and type of construction have paved the way to make the best use of locally available materials by judicious mix proportioning and proper workmanship so as to result in a construction industry satisfying the performance requirements. Proper design of mixes is intended to obtain such proportioning of ingredients that will produce of high durability during the designed life of a structure.
4. High performance does not necessarily require high strength. It is proportioning of mixes, which has low permeability, as possible for particular use that determines the long-term high strength performance behavior of a structure. The construction industry is now slowly becoming aware of the environmental issues and other sustainable development issues for cement and
5. Concrete industries. It is looking for the ways and means to develop building products, which will Increase the life span and quality. It is in this regard that merit of using silica fume ground granulated blast furnace slag; fly ash and rice husk ash have been well recognized by the construction industry.

1 SCOPE OF THE PRESENT INVESTIGATION

The transport of chloride ions into concrete is a complicated and mechanistic phenomenon. It is important to understand some of the basic concepts underlying chloride ingress into concrete to enable the proper consideration of this eventuality when designing structures in extreme environments with reinforced concrete.

At the present time this is the only test method that is widely accepted by concrete industry. As more and more experience is gained with this test as well as with other test methods new procedures may be developed that measure concrete permeability more accurately.This test method covers the determination of the electoral conductance of the concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable to types of concrete where correlations have been established between this test procedure and long term chloride ponding procedures.

This test method covers the laboratory evaluation of the electrical conductance of concrete samples to provide a rapid indication of their resistance to chloride ion penetration. In the most cases the electrical conductance results have shown good correlation with chloride ponding tests. The Permeability of concrete depends on the pore structure of the concrete, while electrical conductivity or resistivity of concrete is determined by both pore structure and chemistry of pore solution .Factors that has little to do with the transport of chloride, can have great effects on electrical conductivity of concrete. Thus, the electrical conductivity or resistivity of concretes cannot be used as an indication of their permeability. However, it can be used as quality control indicators when the concretes have the same components and mixing proportions. Supplementary cementing materials such as silica fume,flyash and ground granulated blast furnace slag may have a significant effect on the chemistry or electrical conductivity of pore solution, depending on the alkali content of the supplementary cementing material, replacement level and age, which has little to do with the chloride permeability.

The effective diffusivity of an ion in a hardened cement and concrete can be related with the electrical conductivity of concrete through some other parameters. However these parameters are too difficult to be determined that it is practically not feasible to use the electrical conductivity of concrete as a direct indication of diffusivity of the ion.

The Rapid chloride permeability test method has proven to be a rapid and effective test method for different types of concrete or concrete containing conductive materials.

2 PRESENT WORK

In the present study we had cement mortar cylinders of 5%, 10%, 15% were casted by replacement of cement with mineral admixtures such as Silica Fume, Ground Granulated Blast Furnace Slag, Fly Ash, Rice Husk Ash and Chemical Admixture such as Super Plasticizer. The method adopted in the investigation used is of as per the code specifications of ASTMC1202-05 and A Standard Equipment of Rapid Chloride Test Apparatus for the determination of permeability of chloride.

From the test results, it can be concluded that permeability of cement when mixed with silica fume is less when compared with other admixtures. However, there is a considerable decrease in permeability when chemical admixtures are used along with mineral admixtures.

3 MATERIALS AND METHODS

3.1 Ordinary Portland Cement (Zuari 43 grade)

The cement used in the casting of cylinders meets the following specifications as per IS 8112-1989.The report was generated by zuari company

QUALITY PARAMETERS

Table: 1 Fineness of Ordinary Portland cement

TEST PHYSICAL REQUIREMENT	ZUARI O.P.C 43 GRADE	IS 8112-1989
SPECIFIC SURFACE (m2/kg)	275	>225

Table: 2 Soundness of Ordinary Portland cement

TEST PHYSICAL REQUIREMENT	ZUARI O.P.C 43 GRADE	IS 8112-1989
Lechatlier Method(mm)	1.5	<10
Auto Clave (%)	0.04	<0.8

Table: 3 Setting Time of Ordinary Portland Cement

TEST PHYSICAL REQUIREMENT	ZUARI O.P.C 43 GRADE	IS 8112-1989
Initial setting time(minutes)	180	>30
Final setting time(minutes)	230	<600

Table: 4 Compressive Strength of Ordinary Portland Cement

TEST PHYSICAL REQUIREMENT	ZUARI O.P.C 43 GRADE	IS 8112-1989
3 Days	32	>23
7 Days	43	>33
28 Days	55	>43

Table: 5 Chemical Requirements of Ordinary Portland Cement

TEST PHYSICAL REQUIREMENT	ZUARI O.P.C 43 GRADE	IS 8112-1989
Loss on ignition (%)	1.55	<5
Insoluble residue (%)	2	<3
Magnesium oxide (%)	1.4	<6
Lime saturation factor	0.87	0.6-1.02
Alumina Iron ratio	1	0.66-1.02
Sulphuric Anhydride (%)	1.9	<3
Alkalies (%)	0.6	-
Chlorides (%)	0.01	<0.1
C_3A	-	5.5

3.2 Portland Slag Cement (Ultratech Cement)

P.S.C is obtained by mixing blast furnace slag, cement clinker and gypsum and grinding them together to get intimately mixed cement. The quantity of slag varies from 30-70%.The cement used in the casting of cylinders meets the following specifications as per IS 455-2002.The report was collected from the ultratech company.

Table: 6 Quality Parameters of Portland Slag Cement

FINENESS	
Specific Surface(m2/kg)	225
SETTING TIME	
Initial Setting Time(min) (Minimum)	30
Final Setting Time(min) (Maximum)	600
COMPRESSIVE STRENGTH(Mpa)	
3 DAYS	16
7 DAYS	22
28 DAYS	33
SOUNDNESS	
Le-chatlier(mm)	10
Auto Clave (%)	0.8

3.3 SILICA FUME

Silica Fume was first tested in 1947, and related tests revealed a variety of potential application benefits. Silica Fume is co-product of the Ferro-silicon alloy industry. The fumes collected from the smoke stack of one of the smelting plants showed a very high content of amorphous silicon dioxide-nearly over 90%, realizing Pozzolanic potential of this material. Silica Fume920-D used in the present study was obtained from Elkem India Pvt. Ltd., Mumbai. The properties of Silica Fume are tabulated.

Table: 7 Properties of Silica Fume 920-D

PARAMETER	Specification	Analysis
Sio_2	% Min 85.0	89.2
Moisture content	% Max 3.0	0.4
Loss on ignition	% Max 6.0	2.2
45 micron	% Max 10	8
Bulk density	500-700 Kg/m^3	0.55

3.4 *Fly Ash*

Most thermal power plants use coal-fired boilers which consume coal ground to a fineness of more than 75% particles of 75µm size. As the fuel travels through the high temperature zone in the furnace, the volatile substances and carbon are burnt off, whereas most of the mineral impurities are fused and remain suspended in the flue gas. Upon leaving the combustion zone the molten ash particles are cooled rapidly from 1500^0C to 200^0C in few seconds and they solidify as spherical, glassy particles. Some of the fused matter agglomerates to form bottom ash, but most of it flies out with flue gas stream and is therefore called fly ash. Subsequently, the fly ash is removed from the flue gas by a series of mechanical separators and electrostatic precipitators or bag filters. Typically, the ratio of fly ash to bottom ash is 70:30 in wet bottom boilers or 85:15 in dry bottom boilers. Due to its unique mineralogical and granulometric characteristics, fly ash generally does not need any processing before use as a mineral admixture. Bottom ash is much coarser, less reactive and therefore requires fine grinding to develop a Pozzolanic property. Average worldwide utilization of fly ash is about 15%, whereas in India, its utilization is from 2 to 5% only. In the present study Fly ash is collected from Ennore thermal power station, Chennai. It is conformed to grade1 of IS: 3812-1981.

Table: 8 Properties of Fly Ash

SL.NO	CHARATERISTICS	PERCENTAGE
1	Silica, SiO_2	49-67
2	Alumina Al_2O_3	16-28
3	Iron oxide Fe_2O_3	10-Apr
4	Lime CaO	0.7-3.6
5	Magnesia MgO	0.3-2.6
6	Sulphur trioxide SO_3	0.1-2.1
7	Loss on ignition	0.4-0.9
8	Surface area m^2/kg	230-600

Table: 9 Chemical Requirements of Fly Ash

S.NO	CHARATERISTICS	REQUIREMENTS	COMPOSITION OF FLY ASH USED
1	Silica + alumina + iron oxide % by mass	70 (min)	94.2
2	Silicon dioxide % by mass	35 (min)	53
3	Magnesium oxide % by mass	5 (max)	1.19
4	Sulphur trioxide % by mass	2.75(max)	0.04
5	Available alkalies as sodium oxide % by mass	1.5 (max)	0.46
6	Loss on ignition	12 (max)	0.34

3.5 Rice Husk Ash

Rice milling generates a byproduct know as husk. This surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice, broken rice and bran .Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica.

Table: 10 Physical Properties of Rice Husk Ash

S.NO	Properties	Result
1	Variety	Mixed
2	Calorific value	3350 Kcal/kg
3	Specific gravity	2
4	Loss on ignition	3.60%
5	Burning	Open
6	Fineness Blains	16000 cm^2/gm

Table: 11 Chemical Analysis of Rice Husk Ash

S.NO	Constituent	Percentage
1	SiO_2	93.2
2	Al_2O_3	0.9
3	Fe_2O_3	0.45
4	MgO	0.4
5	CaO	3.15
6	KO	1.6

3.6 Ground Granulated Blast Furnace Slag

Blast furnace slag is developed during iron production. Iron ore is reduced to a molten state by burning coke fuel with fluxing agents of limestone and/or dolomite. Ground Granulated Blast Furnace Slag (GGBFS) is a glassy, granular material resulting from blast furnace slag being rapidly cooled by water immersion, and pulverized to a fine, cement-like material. Slag is produced from Lanco steel plant, Sri Kalahastri.The report given below is collected from the industry.

Table: 12 Physical Properties of G.G.B.F.S

S.NO	CHARATERISTICS	PROPERITIES OF SLAG USED
1	Specific gravity	2.91
2	Fineness m^2/kg	330
3	Glass content percent	93
4	Bulk density Kg/m^3	1100
5	Color	Dull white

Table: 13 Chemical Composition of G.G.B.F.S

S.NO	COMPOUND	REQUIREMENT (BS:6699)	PROPERITIES OF SLAG USED
1	SiO_2	32-42	33.2
2	Al_2O_3	7.16	18.3
3	CaO	32-45	41
4	Fe_2O_3	0.1-1.5	1.3
5	MgO	14 max	11.6
6	SO_3	2.5 max	1
7	CaO/ SiO_2	1.4 max	1.23
8	Loss on ignition	3 max	0.5

3.7 Super Plasticizer

Super plasticizers are linear polymers containing sulfonic acid groups attached to the polymer backbone at regular intervals. Most of the commercial formulations belong to one of four families:

- Sulfonated melamine-formaldehyde condensates (SMF)
- Sulfonated naphthalene-formaldehyde condensates (SNF)
- Modified lignosulfonates (MLS)Polycarboxylate derivatives

The super plasticizer utilized was supplied by internationally reputed admixtures manufactures. Conplast SP 430 was manufactured by Fosroc. Conplast SP 430 is based as sulphonated naphthalene formaldehyde super plasticizer. It complies with IS: 9103-1999.

Table: 14 Properties of Super Plasticizer

S.NO	Property	Result
1	Form or state	Liquid
2	Colour	Brown
3	Specific gravity	1.22 to 1.225 at 30^{0}C
4	Air entrainment	Approx. 1% additional air is entrapped
5	Compatibility	Can be used with all types of cements except high alumina cement
6	Workability	Can be used to produce flowing concrete that requries no compaction
7	Cohesion	Cohesion is improved due to dispersion of cement particles thus minimizing segregation and improving surface finish
8	Compressive strength	Improvement in strength up to 20% depending up on water cement ratio and other mix parameters
9	Durability	Reduction in w/c ratio enables increase in density and impermeability thus enhancing durability of concrete
10	Dosage	0.5 to 2.0 litres per 100 kg of cement

3.8 Fine Aggregate

The sand used throughout the experimental work was obtained from the river Swarnamukhi near Tirupati, Chittoor district, Andhra Pradesh. The specific particle size composition of the sand was prepared as per the IS 650:1966 and IS 383:1970

Table 15: Properties of Fine Aggregate

S.No	Properties	Unit	Results
1	Specific gravity	-	2.64
2	Bulk density	kN/m^3	15.54
3	Fineness modulus before sieving	-	2.72
4	Particle size variation	mm	0.15 to 2.0
5	Loss of weight with concentrated Hydrochloric acid	%	0.124

3.9 Rapid Chloride Permeability Test (Rcpt)

Table: 16 Determination of Chloride Permeability

CHARGE PASSED IN COLOUMBS	CHLORIDE ION PENETRABILITY
>4000	HIGH
2000-4000	MODERATE TO HIGH
1000-2000	LOW TO MODERATE
100-1000	VERY LOW TO LOW
<100	NEGLIGIBLE

4 RESULTS AND DISCUSSIONS

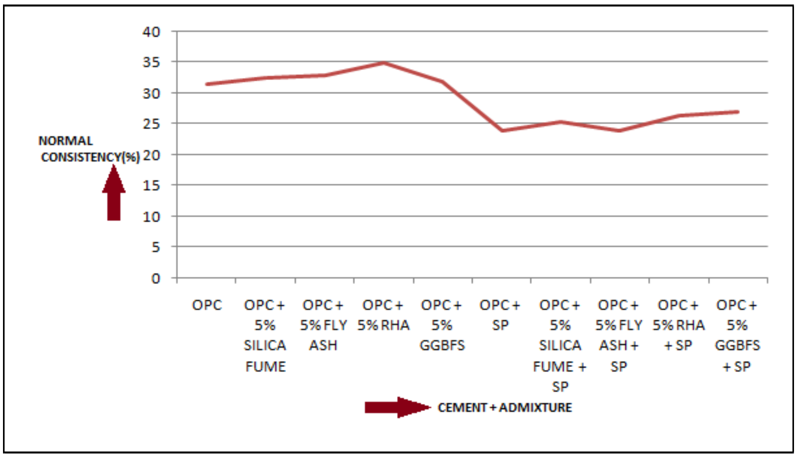
The results obtained from the experimental system were represented both in tabular form and graphical means. A Discussion follows for each result immediately. The discussion is based on the value of the result as well as from the available literature

Table: 17 Normal Consistency Values for 5% Replacement of Ordinary Portland Cement

S.NO	CEMENT + ADMIXTURE	NORMAL CONSISTENCY (%)
1	O.P.C	31.5
2	O.P.C + 5%SILICA FUME	32.5
3	O.P.C + 5%FLY ASH	33
4	O.P.C + 5%R.H.A	35
5	O.P.C + 5%G.G.B.F.S	32
6	O.P.C + S.P	24
7	O.P.C + 5%SILICA FUME + S.P	25.5
8	O.P.C + 5%FLY ASH + S.P	24
9	O.P.C + 5%R.H.A + S.P	26.5
10	O.P.C + 5%G.G.B.F.S + S.P	27

Graph: 1 Effect on Normal Consistency for 5% Replacement of Ordinary Portland Cement

4.1 Effect On Initial, Final Setting Times And Soundness For 5% Replacement Of Ordinary Portland Cement



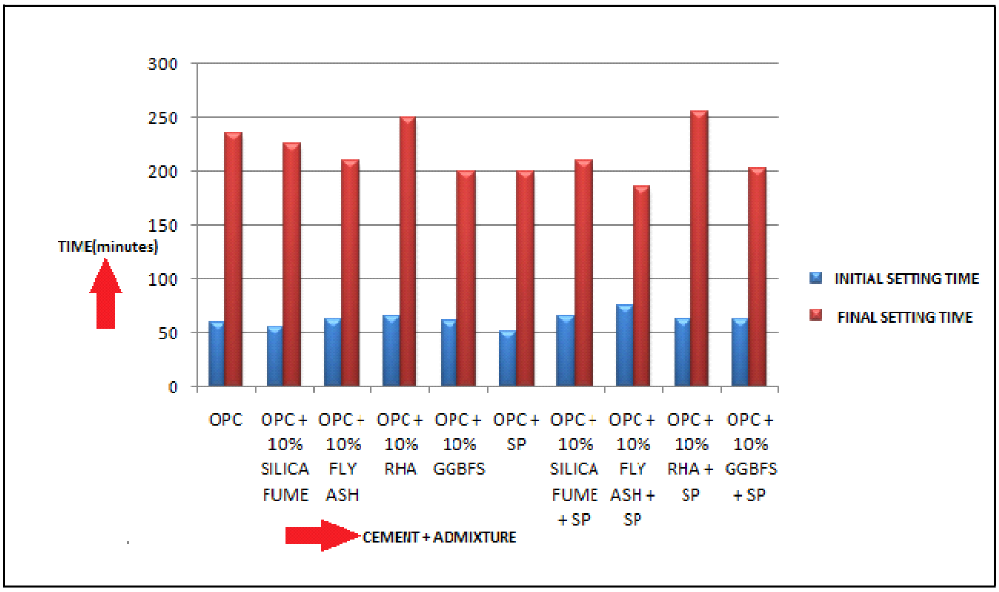
From the table 18 and graph-2 it is noticed that O.P.C replaced with 5% of admixtures had resulted in increase in initial and final setting times for O.P.C mixed with both R.H.A and S.P, however there is a decrease in initial and final setting times for O.P.C mixed with both Silica Fume and S.P.

For the case of Soundness of cement it is more in case of O.P.C mixed with Fly Ash and O.P.C mixed with S.P, but it is less in case of normal O.P.C and O.P.C mixed with R.H.A

Table: 18 Initial, Final and Soundness values for 10% Replacement of Ordinary Portland Cement

S.NO	CEMENT + ADMIXTURE	INTIAL SETTING TIME(min)	FINAL SETTING TIME(min)	SOUNDNESS (mm)
1	OPC	60	235	0.6
2	OPC + 10% SILICA FUME	55	225	4.1
3	OPC + 10% FLY ASH	62	210	0.29
4	OPC + 10% RHA	65	250	0.503
5	OPC + 10% GGBFS	61	200	4.07
6	OPC + SP	51	200	1.8
7	OPC + 10% SILICAFUME + SP	65	209	0.165
8	OPC + 10% FLY ASH + SP	75	186	0.605
9	OPC + 10% RHA + SP	63	255	0.765
10	OPC + 10% GGBFS + SP	62	203	0.565

Graph-2 Effects on Initial and Final Setting time for 10% Replacement of Ordinary Portland Cement

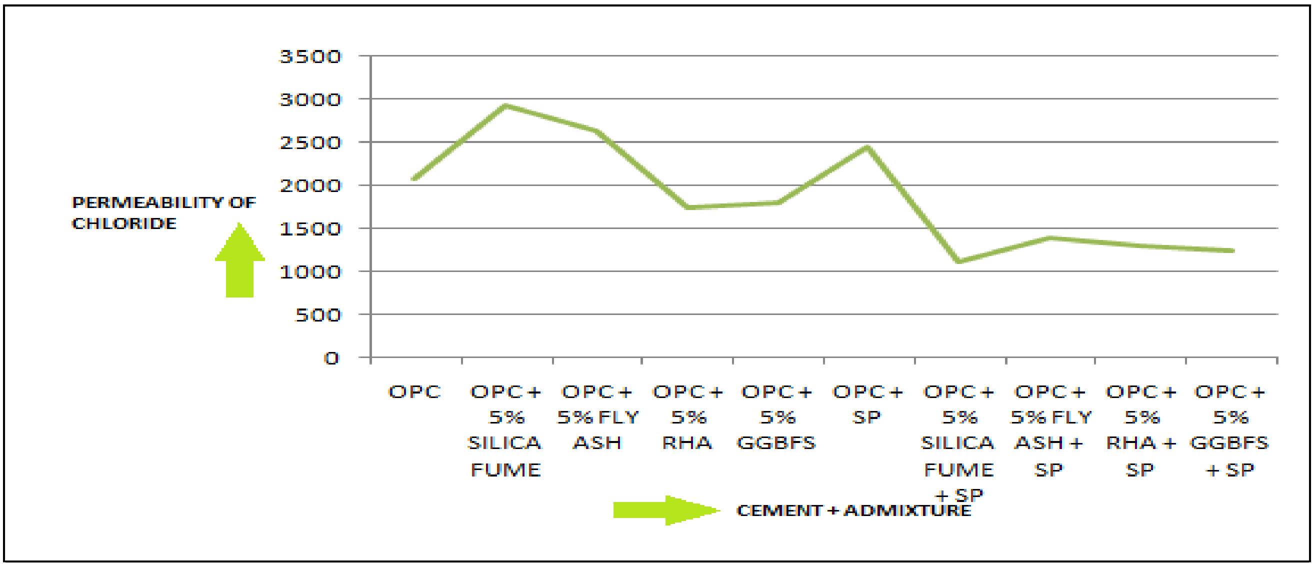


4.2 Results Of Rapid Chloride Permeability Test

Table: 19 Determination of Permeability of Chloride in Ordinary Portland Cement for every 30min interval up to 6hrs by using "RCPT Apparatus"

S.NO	CEMENT + ADMIXTURE	I_0	I_{30}	I_{60}	I_{90}	I_{120}	I_{150}	I_{180}	I_{210}	I_{240}	I_{270}	I_{300}	I_{330}	I_{360}	$I_{CUMULATIVE}$ IN mA	$I_{AVERAGE}$ IN coulombs	PENETRABILITY OF CHLORIDE
1	OPC	8	8	8	8	9	9	9	10	10	11	11	12	12	2.3	2070	MODERATE
2	OPC + 5% SILICA FUME	8	10	9	10	12	11	12	13	17	20	19	17	18	3.26	2934	MODERATE
3	OPC + 5% FLYASH	7	7	8	9	9	11	12	12	14	16	16	19	19	2.92	2628	MODERATE
4	OPC + 5% RHA	1	1	4	5	6	6	6	8	9	11	14	17	19	1.94	1746	LOW
5	OPC + 5% GGBFS	5	5	7	7	8	8	8	8	9	10	10	11	12	1.99	1791	LOW
6	OPC + SP	8	8	9	9	9	9	10	11	12	12	17	17	19	2.73	2457	MODERATE
7	OPC + 5%SILICA FUME + SP	0	0	0	1	1	5	5	6	6	10	11	11	11	1.23	1107	LOW
8	OPC + 5% FLYASH + SP	0	1	1	2	2	6	6	8	8	9	12	14	16	1.54	1386	LOW
9	OPC + 5% RHA + SP	1	1	2	4	5	5	6	6	8	9	10	10	11	1.44	1296	LOW
10	OPC + 5% GGBFS + SP	0	0	0	1	4	4	6	8	8	9	10	12	14	1.38	1242	LOW

Graph-3 Variations in Permeability of Chloride for 5% Replacement in Ordinary Portland Cement



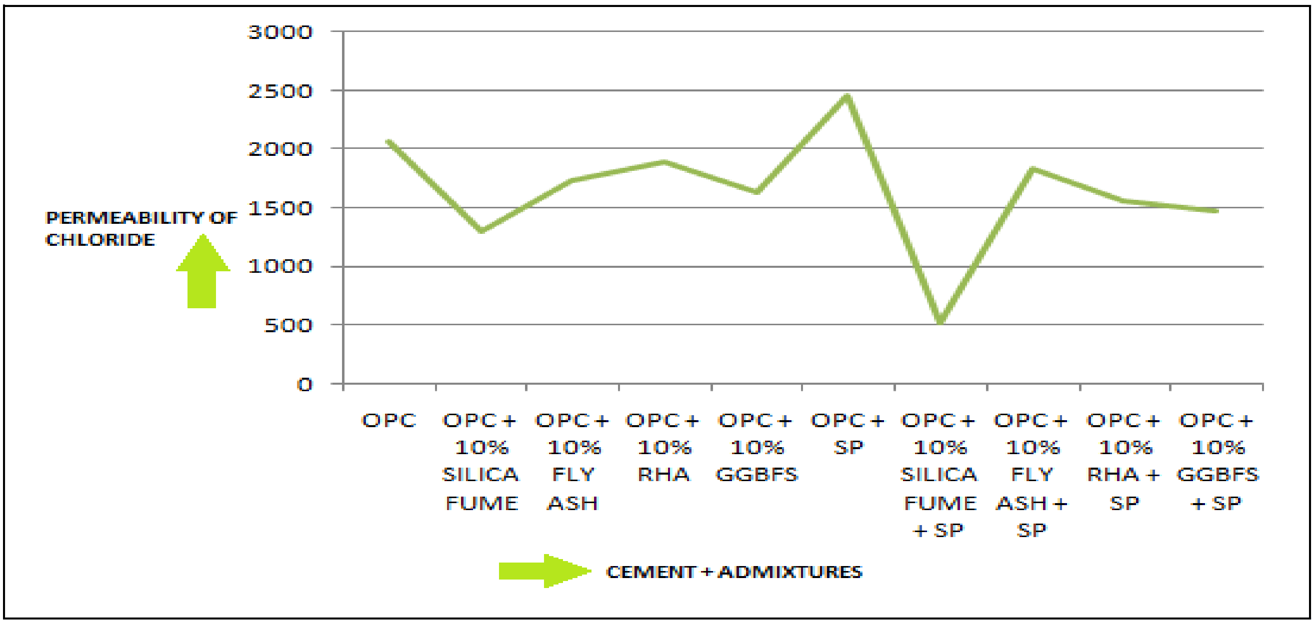
4.3 Effect On Permeability Of Chloride For 5% Replacement Of Ordinary Portland Cement

From the table 20 and Graph-4 it is noticed that O.P.C has less permeability when it is mixed with G.G.B.F.S and R.H.A, its efficiency has been increased when O.P.C is mixed with both mineral and chemical admixtures, this is because the chemical admixtures reduces the water content and increases the workability which in turn results in decrease in permeability.

Table: 20 Determination of Permeability of Chloride in Ordinary Portland Cement for every 30min Interval up to 6hrs by using "RCPT Apparatus"

S.NO	CEMENT + ADMIXTURE	I_0	I_{30}	I_{60}	I_{90}	I_{120}	I_{150}	I_{180}	I_{210}	I_{240}	I_{270}	I_{300}	I_{330}	I_{360}	$I_{CUMULATIVE}$ IN mA	$I_{AVERAGE}$ IN coulombs	PENETRABILITY OF CHLORIDE
1	OPC	8	8	8	8	9	9	9	10	10	11	11	12	12	2.3	2070	MODERATE
2	OPC + 10% SILICA FUME	0	0	1	2	2	4	6	6	8	10	11	14	16	1.44	1296	LOW
3	OPC + 10% FLYASH	0	0	1	4	6	6	8	8	10	14	14	16	19	1.93	1737	LOW
4	OPC + 10% RHA	1	1	5	5	6	6	8	8	11	14	14	18	18	2.11	1899	LOW
5	OPC + 10% GGBFS	2	2	4	4	8	8	9	10	11	12	12	14	16	1.82	1638	LOW
6	OPC + SP	8	8	9	9	9	9	10	11	12	12	17	17	19	2.73	2457	MODERATE
7	OPC + 10%SILICA FUME + SP	0	0	0	1	1	2	2	2	4	4	4	6	6	0.58	522	VERY LOW
8	OPC + 10% FLYASH + SP	0	1	1	2	2	8	8	8	8	12	14	14	16	2.04	1836	LOW
9	OPC + 10% RHA + SP	1	1	1	6	6	8	8	8	9	9	12	12	12	1.73	1557	LOW
10	OPC + 10% GGBFS + SP	0	0	0	4	4	5	8	8	10	11	12	12	16	1.64	1476	LOW

Graph-4 Variations in Permeability of Chloride For 10% Replacement in Ordinary Portland Cement



4.4 *Effect On Permeability Of Chloride For 10% Replacement Of Portland Slag Cement*

From the table 21 and Graph-5 it is noticed that P.S.C has resulted in very less permeability in case of P.S.C replaced with both Silica Fume and S.P, P.S.C replaced with both G.G.B.F.S and S.P when compared to others

Table: 21 Determination of Permeability of Chloride in Portland Slag Cement for every 30min interval up to 6hrs By using "RCPT Apparatus

S.NO	CEMENT+ADMIXTURE	I_0	I_{30}	I_{60}	I_{90}	I_{120}	I_{150}	I_{180}	I_{210}	I_{240}	I_{270}	I_{300}	I_{330}	I_{360}	$I_{CUMULATIVE}$ IN mA	$I_{AVERAGE}$ IN coulombs	PENETRABILITY OF CHLORIDE
1	PSC	9	9	9	9	10	10	11	11	11	14	14	17	17	2.76	2484	MODERATE
2	PSC+15% SILICA FUME	0	0	0	2	6	6	6	7	7	8	10	10	11	1.35	1215	LOW
3	PSC+15% FLYASH	0	1	1	1	6	6	8	10	10	11	12	14	14	1.74	1566	LOW
4	PSC+15% RHA	2	2	5	5	9	9	9	10	10	11	11	13	13	2.03	1827	LOW
5	PSC+15% GGBFS	1	1	1	1	1	3	3	6	6	8	8	10	11	1.08	972	VERY LOW
6	PSC+SP	0	1	1	3	4	4	5	8	9	9	10	10	11	1.39	1251	LOW
7	PSC+15% SILICA FUME+SP	0	0	0	0	1	1	1	1	1	1	2	6	8	0.36	324	VERY LOW
8	PSC+15% FLYASH+SP	1	2	2	2	2	4	4	5	9	9	10	11	11	1.32	1188	LOW
9	PSC+15% RHA+SP	0	0	0	0	0	0	4	5	5	8	8	10	10	0.9	810	VERY LOW
10	PSC+15% GGBFS+SP	0	0	0	0	0	0	0	1	1	1	1	2	2	0.14	126	VERY LOW

Graph-5 Variations in Permeability of Chloride For 15% Replacement in Portland Slag Cement

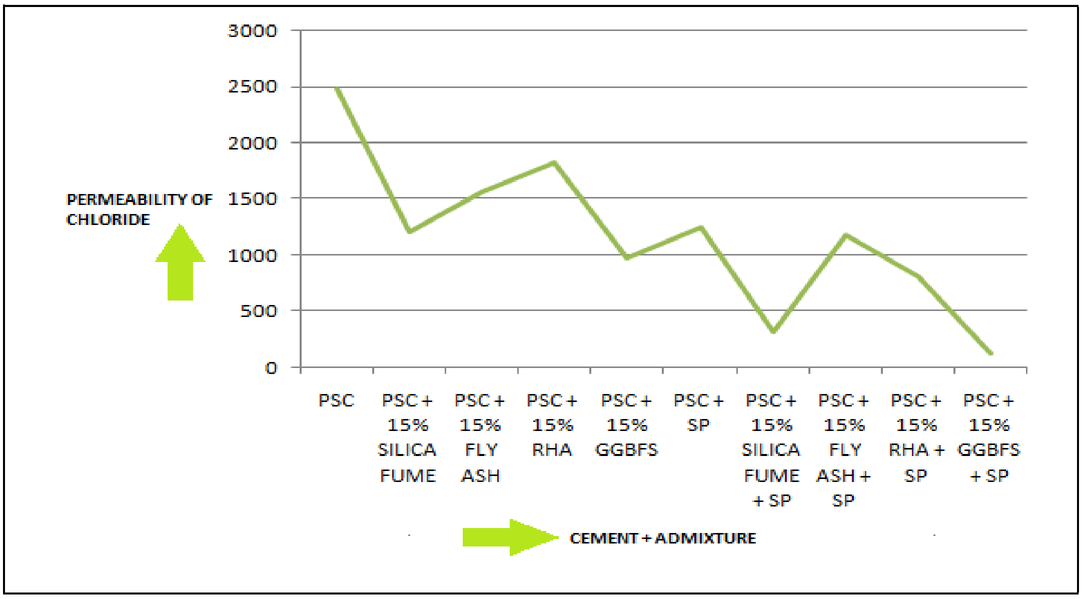
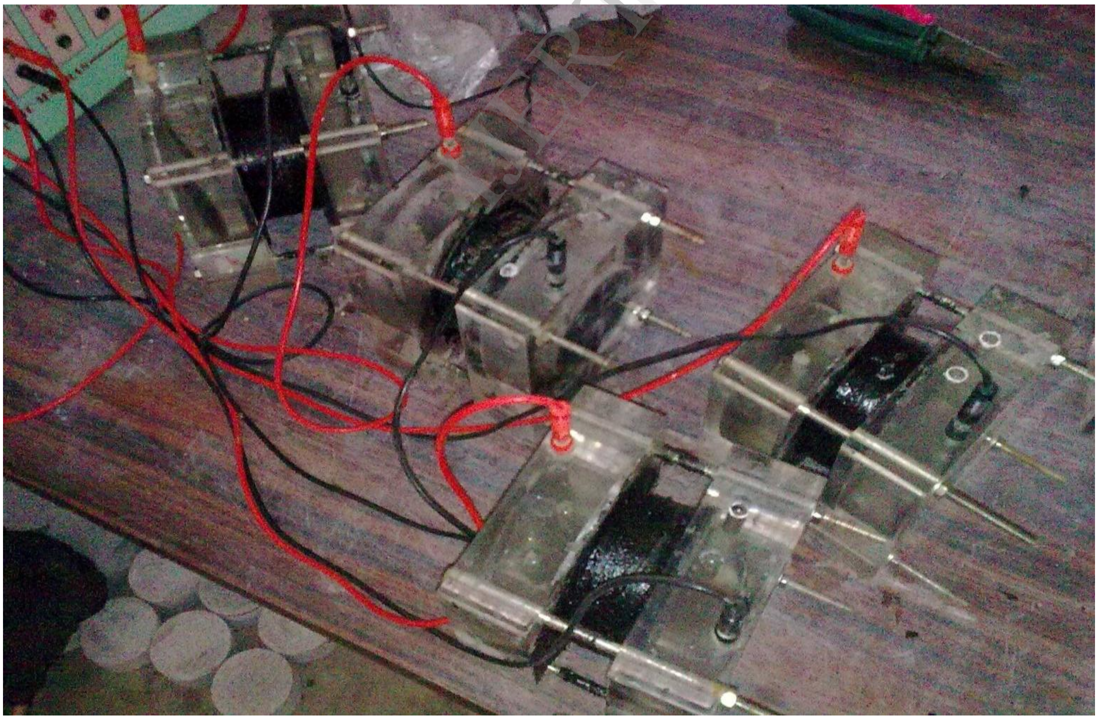


Fig: 1 Specimen Of 5.1cm Thickness Made Ready For Testing

Fig: 2 Standard Rapid Chloride Permeability Test (Rcpt) Apparatus

Fig: 3 Experimental Set Up Of Rcpt Test



CONCLUSIONS

Based on the results obtained in the present investigation the following conclusions can be drawn

1. For Normal Consistency with increase in replacement levels of 5%, 10%, 15% resulted in increase of water content in all the cases but it was more in the case of O.P.C and P.S.C mixed with R.H.A due to the presence of high amount of SiO_2.

2. For initial and final setting times it is found that all the values obtained for the replacement levels of 5%, 10% ,15% are in the permissible range of not less than 20% as per code provisions. Moreover the ratio of final setting time to initial setting time should be in the range of 3 to 5, it is found that all the values are within the range.

3. For Soundness of cement it is observed to be less in case of O.P.C and P.S.C mixed with R.H.A, however for the othercases the soundness are within the limits of not exceeding the 10mm

4. For permeability of chloride it is noticed that Silica Fume yielded good results in decreasing the permeability of chloride followed by other admixtures, however the resistance against chloride can be increased by replacing the cement with both mineral and chemical admixtures

5. From the overall study it is noticed that increase in the replacement of admixtures results in the decrease in permeability as the pores are filled with different types of mineral and chemical admixtures.

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