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Innovative Self-Curing Concrete: Enhancing Durability through RCPT Analysis

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ABSTRACT

To check resistance to chloride ions penetration, we used Electrical resistivity techniques to give an indication of the relative permeability of concrete. The ASTM C 1202 (Standard Test Method for Electrical Indication of concrete's ability to resist chloride lon Penetration), more commonly known as the rapid chloride permeability test (RCPT) Self-compacting concrete (SCC) is a very fluid concrete and a homogeneous mixture. In this project, M40 grade of concrete mixes were made using IS10262:2019. Rapid Chloride permeability test (RCPT) determines the resistance to penetration of chloride ions. It is commonly used to evaluate the resistance of concrete to chloride ions ingress owing to its simplicity and rapidity. It is an electrical indication of concrete's ability to resist chloride ion penetration. It enables the prediction of the service life of concrete structures. Used for durability-based quality control purposes, the constant voltage is applied to a concrete specimen for 6 hours and the current passing through the concrete is recorded to find the coulombs.

Keywords: Rapid Chloride permeability test (RCPT).

I. INTRODUCTION

Rapid Chloride permeability test (RCPT) determines the resistance to penetration of chloride ions. It is commonly used to evaluate the resistance of concrete to chloride ions ingress owing to its simplicity and rapidity. It is an electrical indication of concrete's ability to resist chloride ion penetration. It enables the prediction of the service life of concrete structures. Used for durability-based quality control purposes, the constant voltage is applied to a concrete specimen for 6 hours and the current passing through the concrete is recorded to find the coulombs.

This test determines the electrical conductance of the different grades of concrete mixes and indicates its resistance to the penetration of chloride ions. It monitors the amount of electrical current passed via concrete specimens for a specified time. The movement of ions in a porous medium under a concentration gradient is called diffusion. It is often necessary to ascertain the impermeability of concrete to chloride ions as a quality control measure and assessment of improvements in properties of new concrete. RCPT is measured in Coulomb. Current is measured in Ampere. A Coulomb is an Ampere-second which means one Ampere passed through the concrete specimen in one second is one Coulomb, and the charge passed in 60 seconds would be 60 Coulombs. Higher the Coulomb, higher the permeability and vice versa.

II. MATERIAL

A. Cement

Cement is the binding materials used in building and civil engineering construction. Cements are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields sub-microscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements.

Figure1:Cement

B. Fine Aggregate

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you make the selection of fine aggregate on the basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture.

Figure2:Fine Aggregate

C. Coarse aggregate

Around 70% to 80% of the total volume of the concrete is made up from course aggregates. In lots of construction applications, coarse aggregates perform an integral role, for instance, as a granular base under a slab and as a component in a mixture, such as asphalt or concrete mixtures. Course aggregates are generally categorised as per their shape and size. Depending on the shape they can be round, irregular, angular, flaky, and elongated. Apart from that, depending on the coarse aggregate size you can have gravels. cobble, and boulders in the category. From normal strength to high strength concrete.

Figure3:Coarse Aggregate

D. Super plasticizers

Superplasticizers (SPs) are also known as high range water reducers that are additive used in making high strength concrete. Plasticizers are chemical compounds that enable the production of concrete with approximately 15% less water content. Superplasticizers allow a 30% or more reduction in water content

Figure4:Super Plasticizers

III.RESULTS AND DISCUSSION

Concrete mix samples are tested for RCPT. The observations are taken at 30 minutes time interval and the test is performed for 6 hours, as per ASTM C1202.

A. RCPT of Concrete Mix (0% Superplasticizer)

TABLE I RCPT OBSERPATIONS FOR 1% CHEMICAL ADMIXTURE CONCRETE MIX

	SAMPLE 1		SAMPLE 2	
Time(min)	Current (Ma)	Temperature (Oc)	Current (Ma)	Temperature (Oc)
30	108	32	116	32
60	113	35	121	35
90	117	37	126	37
120	119	39	131	38
150	120	39	133	39
180	120	43	134	39
210	120	44	135	40
240	120	45	134	40
270	118	46	134	40
300	119	47	134	41
330	119	47	133	42
360	117	47	132	43

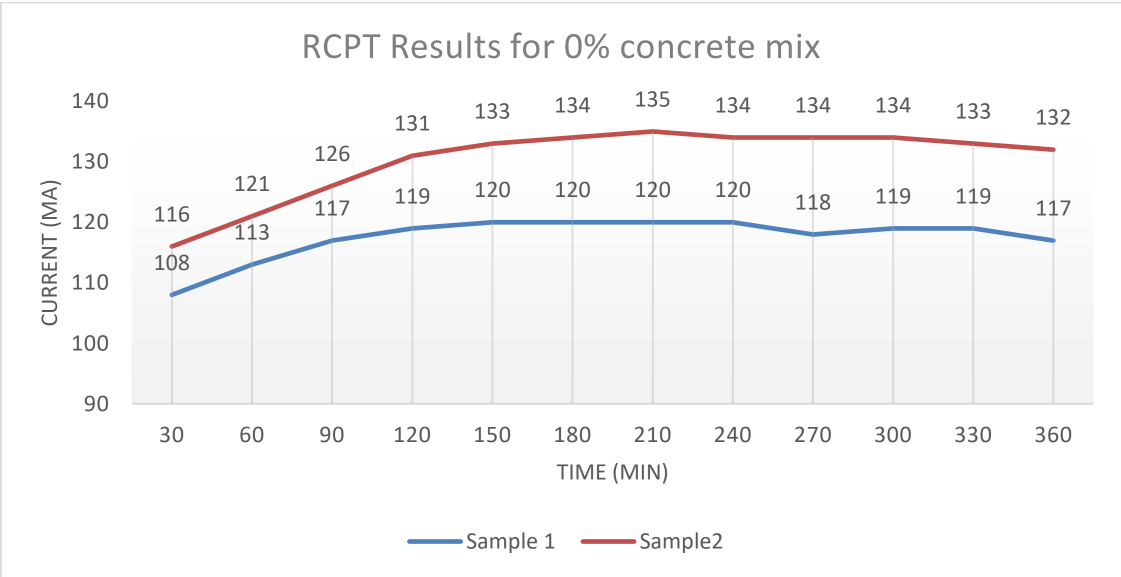

Figure5:RCPT Results for 0% Concrete Mix

For Sample 1.

Q900(108+2*
113+2*117+2+119+2*120+2 120+2*120+2*120 +2*118+2 119+2*119+117)=2335.5 C

Similarly, for sample 2,

Q-2590.2 C

Taking out average of the 2 results,

O=(2335.5+2590.2)/2

Q=2462.85 C→ Medium Chloride Ion Penetrability

B. 1% Chemical Admixture Concrete Mix

TABLE III RCPT OBSERVATIONS FOR 1% CHEMICAL ADMIXTURE CONCRETE

	SAMPLE 1		SAMPLE 2	
Time(min)	Current (Ma)	Temperature (Oc)	Current (Ma)	Temperature (Oc)
30	99	32	77	32
60	105	35	82	35
90	108	37	88	37
120	111	39	92	38
150	113	39	94	39
180	114	43	95	39
210	115	44	96	40
240	115	45	97	40
270	113	46	97	40
300	113	47	97	41
330	112	47	98	42
360	112	47	97	43

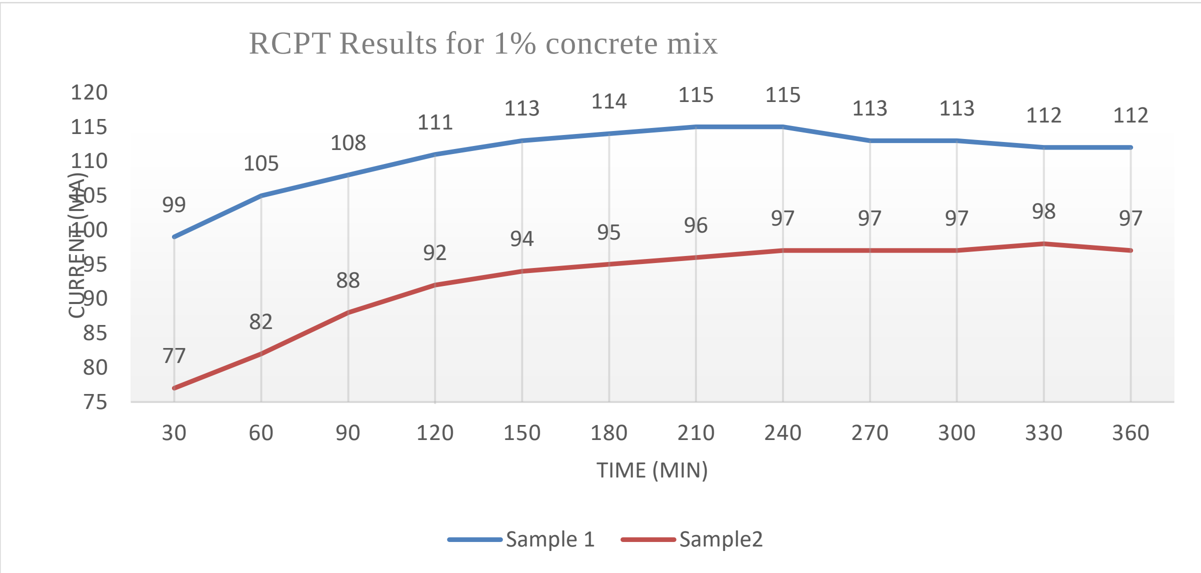

Figure6:RCPT Results for 1% Concrete Mix

As per ASTM C1202,

Q=900(I30+2I60+2I90+…+2I300+2I330+I360) * 10-3

For Sample 1,

Q = 900 (99 + 2*105 + 2*108 + 2*111 + 2*113 + 2*114 + 2*115 + 2*115 + 2*113 + 2*113 + 2*112 + 112) * 10-3

Q = 2204.1 C

Similarly, for sample 2,

Q = 1841.4 C

Taking out average of the 2 results,

Q = (2204.1+1841.4)/2

Q = 2022.75 C → Medium Chloride Ion Penetrability.

C. 1.5% Chemical Admixture Concrete Mix

TABLE IIIII RPCT OBSERVATIONS FOR NORMAL (1.5%) CONCRETE MIX

	SAMPLE 1		SAMPLE 2	
Time(min)	Current (Ma)	Temperature (Oc)	Current (Ma)	Temperature (Oc)
30	99	32	97	32
60	101	35	99	35
90	103	37	102	37
120	105	39	105	38
150	107	39	105	39
180	107	43	105	39
210	107	44	105	40
240	107	45	104	40
270	106	46	105	40
300	105	47	105	41
330	105	47	105	42
360	104	47	105	43

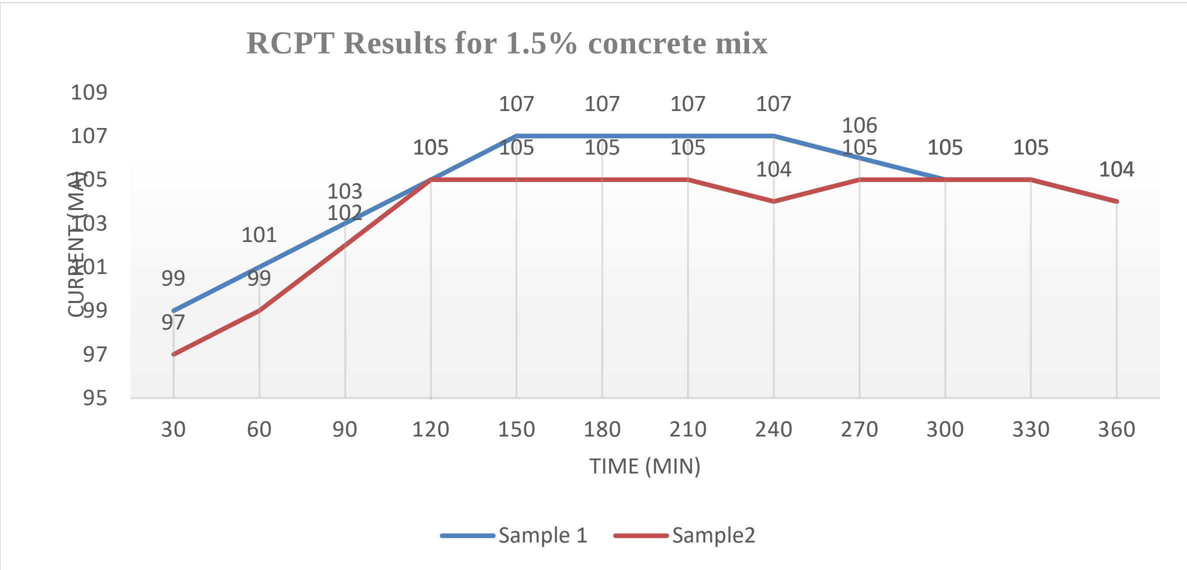

Figure7:RCPT Results for 1.5% Concrete Mix

As per ASTM C1202,

Q900(130+2100+2100 +21300+21330+1300) 10

For Sample 1.
Q=2078.1 C
Similarly, for sample 2,
Q2052.9 C
Taking out average of the 2 results,
Q(2078.1+2052.9)/2
Q2065.5 C→ Medium Chloride Ion Penetrability

D. 2%Chemical Admixture Concrete Mix

TABLE IVV RCPT OBSERVATIONS FOR 2% CHEMICAL ADMIXTURE CONCRETE MIX

	SAMPLE 1		SAMPLE 2	
Time(min)	Current (Ma)	Temperature (Oc)	Current (Ma)	Temperature (Oc)
30	93	32	84	32
60	96	35	87	35
90	98	37	91	37
120	101	39	94	38
150	103	39	95	39
180	104	43	95	39
210	104	44	94	40
240	104	45	94	40
270	103	46	93	40
300	104	47	93	41
330	103	47	93	42
360	103	47	92	43

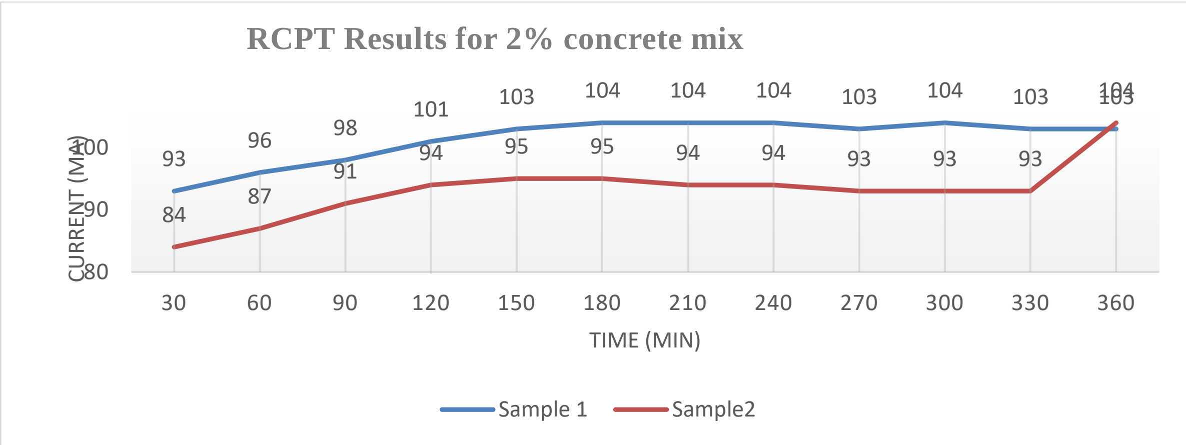

Figure8:RCPT Results for 2% Concrete Mix

As per ASTM C1202, Q900(130+2160+2150++21300+21330+1360)*103
For Sample 1.
Q=2192.4 C
Similarly, for sample 2,

Q=1830.6 C

Taking out average of the 2 results,

Q 2011.5C→ Medium Chloride Ion Penetrability6

E. RCPT Summary

TABLE V RCPT SUMMARY

Concrete Mix	Charge (Coulombs)	Chloride Ion Penetrability
0% Replacement	2462.85	Medium
1% Replacement	2022.75	Medium
1.5% Replacement	2065.5	Medium
2% Replacement	2011.5	Medium

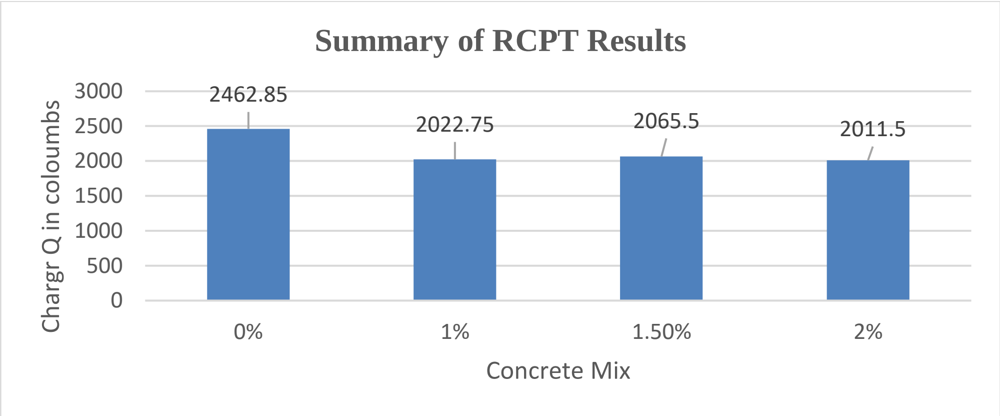

Figure9:Summary of RCPT Results

Figure10:

Self-Consolidating Concrete (SCC) mixes exhibit enhanced resistance to the penetration of chloride ions. In general, the inclusion of superplasticizer in concrete reduces its susceptibility to chloride ion penetration.
Concrete mixes that incorporate aluminium powder and concrete mixes containing aluminium powder cured in saline water are more prone to corrosion compared to self-compacting concrete. Furthermore, between the two samples, the one cured in saline water displays higher readings indicating increased susceptibility to corrosion compared to the sample cured in normal water.

IV. CONCLUSION

The charge transferred values for different replacement percentages of cement by superplasticizer in RCPT were 2462.85C (0%), 2022.75C (1%), 2062.5C (1.5%), and 2011.5C (2%), indicating medium chloride ion penetration.
Self-Compacting Concrete (SCC) mixes exhibit greater resistance to chloride ion penetration compared to normal concrete mixes, implying that a higher concentration of superplasticizer reduces susceptibility to chloride ion penetration.
The concrete mix with 2% replacement of aluminium powder displayed a charge transferred value of 2486.7C, while the sample with aluminium powder cured in saline water exhibited a charge transferred value of 3028.5C. The presence of aluminium powder increases the porosity of concrete, thereby rendering it more susceptible to chloride ion penetration.
The mix containing aluminium powder and cured in saline water demonstrates a more than 25% increase in charge transferred in RCPT compared to the normal concrete mix.

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