(ISO 9001:2015)

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National Council for Cement and Building Materials
(Under the Administrative Control Ministry of Commerce & Industry, Govt. of India)
34 Km Stone, Delhi-Mathura Road (NH-2), Ballabgarh - 121004, Haryana, India

निर्माण विकास एवं अनुसंधान केन्द्र
राष्ट्रीय सीमेंट एवं भवन सामग्री परिषद्
(भारत सरकार के वाणिज्य एवं उद्योग मंत्रालय के प्रशासनिक शासनाधीन)
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By Speed Post/Email

Ref: CDR/SP-6615/Final
29 April 2025

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Through: PN Ojha Joint Director & HOC-CDR

Sub: Performance Evaluation of Bipolar Corrosion Inhibiting Admixture- "CORROSTOP-15" in Concrete.

Ref: Our proposal with reference CDR/SP-0/Rev dated 30.10.2023
Your email dated 3.10.2023, & 27.10.2023, 31.10.2023, 21.11.2023
Our email dated 21.11.2023
Online meeting dated 9.10.2023
Earlier Proposal dated 18.10.2023
Interim report dated 01.03.2024

Dear Sir,

We are pleased to enclose herewith **"Final Report"** of the above said work. This report will supersede the interim report dated 01.03.2024

Thanking you

Yours faithfully
For National Council for Cement and Building Materials

Puneet Kaura
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PERFORMANCE EVALUATION OF BIPOLAR CORROSION INHIBITING ADMIXTURE "CORROSTOP-15" IN CONCRETE

FOR

Laal Chemicals

CDR/SP-6615
April 2025
FINAL REPORT

Centre for Construction Development and Research
NATIONAL COUNCIL FOR CEMENT AND BUILDING MATERIALS
34 Km Stone, Delhi-Mathura Road, NH-2, Ballabgarh – 121 004 (Haryana)

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1.0 INTRODUCTION

The sponsor Laal Chemicals requested National Council for Cement and Building materials (NCB) to take up testing and Performance Evaluation of Bipolar Corrosion Inhibiting Admixture "CORROSTOP-15" in concrete with the scope of work as mentioned below:

2.0 SCOPE OF WORK

Following tests were conducted to evaluate the Performance of corrosion inhibiting admixture corrostop-15:

i. Modified Accelerated Corrosion Test (Based on Japanese Standard JIS Z1535):
ii. Immersion Test for 720 hrs. (Rebar weight loss method)
iii. Effect of Corrosion inhibiting admixture on fresh and hardened concrete.
iv. Polarization Test by Tafel Polarization with 3.5 % NaCl, for 20 days
v. Effect of Corrosion inhibiting admixture in resisting chloride ion penetration as per AASTHO T259
vi. Effect of Corrosion inhibiting admixture in resisting chloride ion penetration as per ASTM C1202
vii. Long Term Corrosion Test as per G-109

3.0 MATERIAL RECEIVED

The material was received on 21.11.2023 for the performance evaluation of corrosion inhibitor:

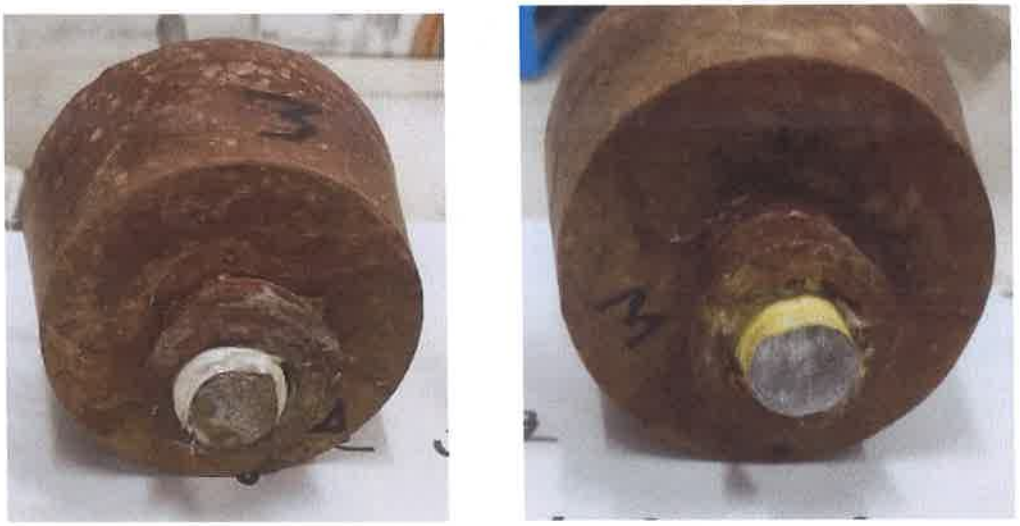
Sl. No.	Material description	Quantity received (approx.)
1	Bipolar corrosion Inhibiting admixture corrostop-15	05 ltrs.

Note: Other concrete making materials for mix design were arranged by NCB Ballabgarh.

4.0 TEST RESULTS & DISCUSSION

4.1 Modified Accelerated Corrosion (Based on Japanese standard JIS Z1535)

Testing Procedure -To carry out accelerated corrosion test, the test specimen of steel (sized approx. 16 mm dia & 12mm thickness) was drilled from one side c/c to hold the aluminium pipe. This setup was then inserted into a rubber stopper which was kept firmly in a 1 litre Glass bottle. The whole setup of two test specimens i.e., control sample (without corrosion inhibiting admixture) and sample with corrosion inhibiting admixture (@25ml Corrosion inhibiting admixture) was subjected to conditioning as per procedure laid down in JIS Z1535. At the end of the test, corrosion spots observed in both control sample and with corrosion inhibiting admixture were noted. All testing was conducted under laboratory environment, temperature of (27±2) °C and at relative humidity of (65±5) %.



(a) (b)

Fig 1: Corrosion spots after Modified Accelerated Corrosion testing of (a) control sample and (b) sample with corrosion inhibitor.

Observations – From the photographs, it can be seen that with bipolar corrosion inhibiting admixture "CORROSTOP-15", corrosion spots are significantly lesser in comparison to control sample.

4.2 Immersion Test for 720hrs (Rebar weight loss method)

a. **Testing Procedure** -To carry out immersion test, three test specimens (steel) were immersed in raw water & three test specimens were immersed in raw water containing corrosion inhibiting admixture (at dosage of 1%, w/w). The weight loss in both type of specimens were measured & the corrosion rates were calculated in mpy (mils per year) as per procedure laid down in ASTM G-1

b. **Test results** -Results are discussed under table 1.

Table 1. Immersion Test for 720hrs (Rebar weight loss method

Sr. no	Sample ID	Corrosion rate Mils per year (MPY)
1.	Control	3.0974
2.	Bipolar Corrosion inhibiting Admixture (CORROSTOP-15)	1.9220

Observations – From the test results, it can be seen that with bipolar corrosion inhibiting admixture (CORROSTOP-15) corrosion rate is lesser in comparison to control sample.

4.3 Effect of corrosion inhibiting admixture on fresh and hardened properties:

a.) Concrete Mix Design:

Concrete mix corresponding to M35 grade was designed for 100mm slump using graded 20mm aggregates (i.e. Coarse aggregate-blending 20mm & 10mm), fine aggregate, OPC 43G cement, GGBS and chemical admixture. The designed control mix was denoted as CM 35. Further in mix CM 35, corrosion inhibitor was added as per the dosage provided by the sponsor, keeping all other constituents same, refer to **table 2**. The mix was denoted as CI 35.

Therefore, in total 2 no's concrete mixes were covered in the study as given below:

- CM35 - Control mix (without Bipolar corrosion inhibiting admixture)
- CI 35 - Concrete Mix with Bipolar corrosion inhibiting admixture i.e. Dosage level recommended by the sponsor.

Concrete making materials such as Cement, Coarse aggregate (20 mm and 10 mm) and fine aggregate were evaluated for basic physical parameters only that are essential for the concrete mix design.

Note: *The dosage of bipolar corrosion inhibiting admixture was provided by the sponsor = 250ml per bag of cement of 50kg, ref email dated 21 Nov 2023.*

Table 2: Concrete mix proportion

Mix Constituents	CM35	CI35
	Quantity (kg/m^3)	Quantity (kg/m^3)
Total Cementitious content	381	381
Cement (OPC 43 Grade)	229	229
Ground Granulated Blast furnace slag (GGBS)	152	152
Water	160	160
Fine Aggregate (crushed)	758	758
Coarse Aggregate -20-10mm (60%)	711	711
Coarse Aggregate -10-4.75mm (40%)	471	471
Chemical Admixture @ 0.70% by wt. of cementitious content	2.670	2.670
Bipolar Corrosion Inhibiting admixture i.e. CORROSTOP-15@0.50% by weight of cementitious content	Nil	1.91
Water – Cementitious Ratio	**0.420**	**0.420**

b.) Physical properties of cement:

The cement sample (OPC-43 Grade, brand –Ultratech tested for various physical properties and the test results are presented in **Table 3**. On perusal of test results, it is seen that: The physical test results of OPC- 43 conform to the various requirements of IS: 269 -2015.

Table 3: Physical properties of cement

Sl. No.	Physical Properties	*Results obtained*	Permissible limits as per IS: 269-2015
1	Blain's fineness, m^2/kg	296	225.0 (Min.)
2	Setting time, minutes Initial Final	 135 200	 30.0(Min.) 600.0 (Max)
3	Compressive strength, N/mm^2 3 days 7 days 28 days	 33.5 45.0 56.5	 23.0 (Min.) 33.0 (Min.) 43.0 (Min.) 58.0(max)
4	Specific Gravity	3.15	-
5	Standard Consistency	24.4%	-
6	Soundness (By Le-chatelier exp.) in mm	1.0	10.0(Max.)

c.) Physical Properties of GGBS:

The sample of ground granulated blast furnace slag (GGBS) tested for various physical properties like specific gravity and fineness. On perusal of test results, it is seen that the fineness of the GGBS is 369 which conform to the requirement of IS: 16714 whereas specific gravity of ggbs is 2.88.

d.) Physical tests on coarse aggregates and fine aggregates:

The following physical properties were conducted on one coarse aggregate and fine aggregates sample as per IS: 2386-1963. The physical properties of coarse and fine aggregates are given below in the **table 4.**

Table 4: Physical properties of coarse and fine aggregate

Property		Coarse Aggregate		Fine Aggregate
		20 mm	10 mm	
Specific gravity		2.80	2.78	2.86
Water absorption (%)		0.31	0.28	0.57
Sieve Analysis Cumulative Percentage Passing (%)	20mm	93	100	100
	10 mm	9	92	100
	4.75 mm	-	10	100
	2.36 mm	-	1	91
	1.18 mm	-	-	66
	600 µ	-	-	48
	300 µ	-	-	34
	150 µ	-	-	22
	Pan	-	-	-

The coarse aggregate sample (20 mm and 10 mm) and fine aggregates conforms to the various requirements of IS: 383-2016.

To study the effect of corrosion inhibiting admixture on various fresh and hardened properties of concrete, investigation was carried out on M35 grade of concrete with and without corrosion inhibiting admixture (At dosage level recommended by the sponsor). The following tests were performed and details are mentioned below

4.3.1. Visual observation

No bleeding and segregation were observed in both concrete mixes (CM35 and CI35). Addition of Bipolar Corrosion Inhibiting Admixture i.e., Corrostop-15, did not cause bleeding and segregation in concrete.

4.3.2. Workability:

Initial slump and workability @30 min interval up to 2 hours was measured for workability loss and slump retention. The slump test on fresh concrete was carried out using a mould in the form of frustum of a cone having internal dimensions as bottom diameter of 200 mm, top diameter of 100 mm and height of 300 mm. The internal surface of the mould was thoroughly cleaned and freed from superfluous moisture and any set concrete before

commencing the test. The mould was placed on a smooth, horizontal rigid and non-absorbent surface and was firmly held in place while it was being filled. The mould was filled in 3 layers, each approximately one-third of the height of the mould. Each layer was tamped with twenty-five strokes of the rounded end of the tamping rod. After the top layer was rodded, the concrete was struck off level with a trowel. The mould was then removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allowed the concrete to subside and the slump was measured immediately. The slump measured was recorded in terms of millimeters of subsidence of the specimen during the test. The slump test (workability) results of mix are given in **Table 5**.

Table 5: Workability loss of concrete mixes

Time (Minutes)	Slump value of Concrete mix CM35 (in mm)	Slump value of Concrete mix CI35 in mm
Initial (0)	110	100
30 minutes	85	80
60 minutes	65	50
90 minutes	45	25
120 Minutes	20	10

Observation: Initial slump and slump loss with respect to time for control concrete (i.e. CM35) and concrete containing Bipolar corrosion inhibiting admixture i.e., CORROSTOP-15 (i.e. CI35) was found to be similar. Addition of Bipolar corrosion inhibiting Admixture i.e., CORROSTOP-15 did not have significant negative effect on workability of concrete.

4.3.3. Initial and final setting time:

The setting time of concrete was determined as per IS: 1199. In this test, all of the mortar from the sample of concrete was removed by sieving through a 4.75 mm IS sieve. The mortar was thoroughly mixed by hand and placed in cube specimens in three layers and compacting each layer by a tamping rod. The mortar surface was 10 mm below the top edge of the cube specimen to provide space for the collection ad removal of bleeding water. The

bleeding water was removed from the surface of the mortar specimens just prior to making a penetration test by means of a pipette.

A needle of appropriate size, apparatus was inserted. The bearing surface of the needle was brought in contact with the mortar surface. After that, a vertical force was applied gradually and uniformly on the apparatus so that the needle penetrates the mortar to a depth of 25 mm. The time required to penetrate to the 25 mm depth should be 10 seconds. The force required and the time of application, measured as elapsed time after initial contact of water and cement. The initial and final setting time is the elapsed time to reach a penetration resistance of 3.43 N/mm^2 or 34.97 kgf/cm^2 and 26.97 N/mm^2 or 275.01 kgf/cm^2 respectively. The initial and final setting time of fresh concrete for both concrete mixes at CM35 and CI35 as shown in figure 2.

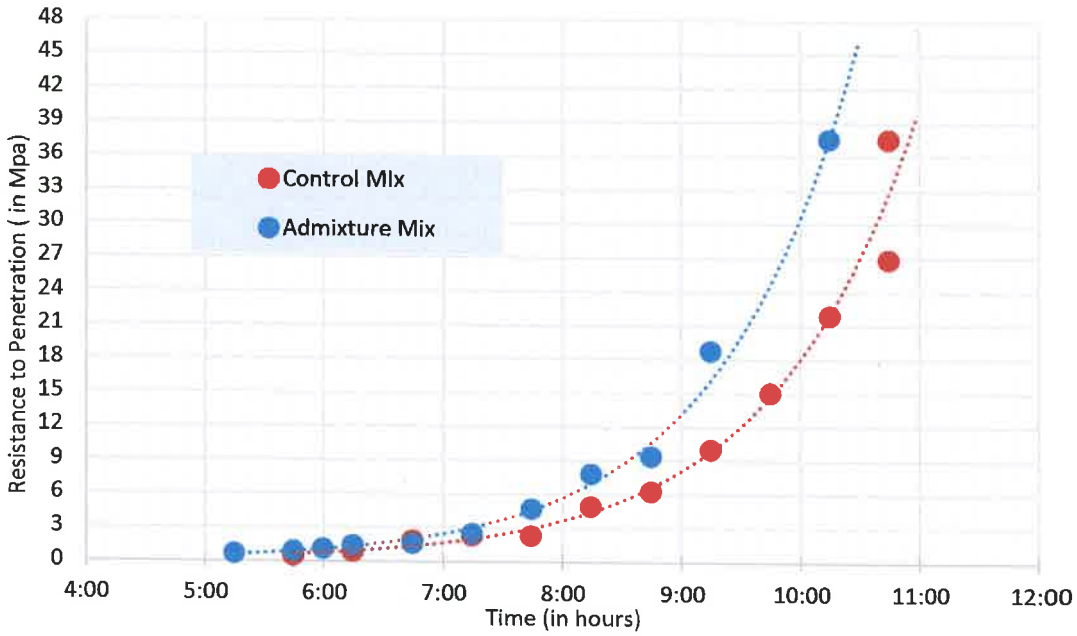


Fig 2: Initial and final setting time of fresh concrete

Observation: The initial setting time of control concrete i.e. CM35 and concrete containing Bipolar corrosion inhibiting admixture i.e., CORROSTOP-15 i.e. CI35 was observed as 480 minutes and 450 minutes respectively. The final setting time of control concrete mix CM35 and concrete containing Bipolar corrosion inhibiting Admixture i.e., CORROSTOP-15 i.e. CI35 was observed as 630 minutes and 590 minutes respectively.

It has been observed that addition of Bipolar corrosion inhibiting Admixture i.e., Corrostop-15, led to a little decrease in initial and final setting time of concrete.

4.3.4. Compressive strength:

a. **Testing Procedure**: To study the effect of corrosion inhibiting admixture on compressive strength, three test specimens (150x150x150mm) with and without corrosion inhibiting admixture were cast. The test specimens were water cured and tested at 1 day, 3 days, 7 days & 28 days as per IS 516 (Part 1/section 1)

b. **Test Results:** Test results are discussed under **Table 6**.

Table 6: Results for Compressive Strength

Sample Id	Compressive strength (MPa)			
	1-day	3-days	7-days	28-days
CM35 (Control concrete)	6.83	23.00	35.17	48.50
CI35(Concrete with Bipolar Corrosion inhibiting Admixture "CORROSTOP-15")	6.00	27.33	40.17	49.17

Observation: From the Table 6, the compressive strength of concrete mixes i.e. CM35 (control mix) and CI35 (Concrete containing Bipolar corrosion inhibiting admixture i.e., "CORROSTOP-15") was found to be comparable at each age of testing. Addition of Bipolar corrosion inhibiting admixture in concrete i.e., Corrostop-15 did not have any negative effect on the compressive strength of concrete.

4.3.5 Flexural Strength:

a. **Testing Procedure**: To study the effect of corrosion inhibiting admixture on Flexural strength, three test specimens (100 mm x100mm x500mm) with and without corrosion inhibiting admixture were cast. The test specimens were water cured and tested at 3 days,7 day & 28 days as per IS 516 (Part 1/section 1).

b. **Test Results:** Test results are discussed under **Table 7.**

Table 7: Result for Average Flexural strength (MPa)

Sample Id	Flexural Strength (MPa)		
	3-days	7-days	28-days
CM35 (Control concrete)	3.45	4.10	7.82
CI35(Concrete with Bipolar Corrosion inhibiting Admixture "CORROSTOP-15")	3.82	4.86	8.57

Observation: From the Table 7, the flexural strength of concrete mixes i.e. CM35 (control mix) and CI35 (Concrete containing Bipolar corrosion inhibiting admixture i.e., "CORROSTOP-15") was found to be comparable at each age of testing. Addition of Bipolar corrosion inhibiting admixture in concrete i.e., Corrostop-15 did not have negative effect on the flexural strength of concrete.

4.3.6 Change in Length (Drying Shrinkage):

a. The drying shrinkage is the difference between the original wet measurement and dry measurement which is expressed as a percentage of dry length of the rectangular moulded sample and was determined as per IS 516 part 6.

- A total of 6 number of concrete specimens of cross section 75×75 mm and length 300 mm were casted, 3 each with mixes CM35 and CI35 and after 24 hours the specimens were demoulded and kept in moist air for 7 days.
- At the conclusion of the period of storage in moist air, the specimens were immersed in water (27±2 °C) until an age of 28 days after the concrete was made.
- After 28 days, the reading for mass (to an accuracy of 0.1g) and length (to an accuracy of 0.001 mm) were taken. The length of the specimen at this stage is denoted as initial length.
- The specimens were then dried in oven at temperature 49°C to 51°C and humidity 17 % RH for 44 hours and later cooled for 4 hours.

Final length after drying will be noted for all the specimens. The drying shrinkage is reported as the percentage reduction in length after drying w.r.t. original effective gauge length before drying.

b. **Test results:** Test results are discussed under **Table 8**

Table 8: Result for Drying Shrinkage

Sample Id	Drying Shrinkage (%)
CM35 (Control concrete)	0.0227
CI35(Concrete with Bipolar Corrosion inhibiting Admixture "CORROSTOP-15")	0.0174

Observation: As presented in Table 8, the drying shrinkage of CI35 (concrete incorporating the bipolar corrosion inhibiting admixture, CORROSTOP-15) was observed to be lower than that of the control mix, CM35. This result suggests that the inclusion of CORROSTOP-15 does not adversely affect the drying shrinkage characteristics of concrete.

4.4 Polarization Test by Tafel Polarization with 3.5% NaCl, for 20 days

a. **Testing Procedure** -Two concrete slabs of size 350mm x 250mm x 100mm length each with & without corrosion inhibiting admixture of M35 grade was cast. In each of these specimens, clean rebar conforming to IS: 1786 of size 300 mm length and 12mm diameter was placed. The specimens after demoulding were cured for 28 days. After completion of the curing period, the specimens were kept in 3.5% NaCl solution for 20 days. After that polarization test was carried out & observations were recorded. For electrochemical measurements in this test, sign conventions were used as per ASTM G-3.

b. **Test results** – Test results are discussed in **Table 9**.

Table 9: Polarization Test by Tafel Polarization

Sr. No	Sample ID	mils/year
1.	CM35 (Control concrete)	**0.1889**
2.	CI35(Concrete with Bipolar Corrosion inhibiting Admixture "CORROSTOP-15")	**0.1347**

Note: 1 mm/year = 39.37 mils/year

Observations – From the test results given in table 9, it can be seen that corrosion rate of the concrete made with bipolar corrosion inhibitor (CORROSTOP-15), CI 35 is lower than that of control concrete, CM 35.

4.5. Effect of corrosion inhibiting admixture in resisting chloride ion penetration as per AASTHO T259:

a. To study the effect of corrosion inhibiting admixture in resisting chloride ion penetration salt ponding test as per AASTHO T259) in case of M35 grade of concrete, three test specimens (slab with dimensions 300*300*100mm) with and without corrosion inhibiting admixture were cast.

b. *Testing Procedure for Chloride ion penetration test as per AASTHO T259*

i. The test specimens were water cured for 14 days and thereafter specimens were conditioned up to an age of 28days under laboratory environment of temperature of (27+2)^{0}C and at relative humidity of (65+5) %.

ii. The test specimens after conditioning were ponded with 3% NaCl solution on the top surface for 90 days' exposure period.

iii. Core of diameter 60 mm were drilled out from each of the three slab of both samples and then disk of 10 mm height were sliced upto 30 mm depth.

iv. The disk samples were grinded to the size finer than 90 microns.

v. Then the powdered samples were tested for total acid soluble chloride content as per IS: 14959 part 2 for depth level up to 30 mm

vi. Average of three specimens for each depth with standard deviation has been reported

c. **Test results -** Test results are discussed in **Table 10.**

Table 10: Tests results of Total Acid Soluble chloride content (%)

Depth (in mm)	CM 35 (Control)	CI 35 (Concrete with Bipolar Corrosion inhibiting Admixture "CORROSTOP-15")
10	0.247 ±0.038	0.197 ±0.037
20	0.033 ±0.020	0.035 ±0.003
30	0.033 ±0.013	0.016 ±0.004

Observation: From test results as shown in table 10, it can be observed that acid soluble chloride content (%, by weight of concrete) values for M35 grade of concrete were less for concrete made with corrosion inhibitor ("CORROSTOP-15") i.e. CI 35 as compared to control sample without corrosion inhibitor (CM 35). Further, it can be said that with the addition of bipolar corrosion Inhibitor ("CORROSTOP-15") enhances the resistance of concrete against ingress of chloride ion.

4.6. Effect of Corrosion inhibiting admixture in resisting chloride ion penetration as per ASTM C1202:

a. To the effect of corrosion inhibiting admixture against chloride ion penetration resistance as per ASTM C1202 in case of M35 grade of concrete, three test specimens (50mm thick and 100 mm diameter) with and without corrosion inhibiting admixture were cast. The test specimens were water cured for 28 days and thereafter will be tested as per ASTM C1202.

b. *Testing Procedure adopted for RCPT is as per ASTM C 1202*

i. This test was conducted on saturated concrete specimens ,50mm thick slice of 100mm diameter extracted from the concrete specimen (of dia=100mm and length=200mm) during testing.

ii. A potential difference of 60V DC was maintained across the ends of the specimen, one end immersed in 3.0% NaCl solution and the other end in 0.3M NaOH solution.

iii. The apparatus and the cell arrangement are shown in Figure 3. The total charge passed (in coulombs) is determined and is related to the chloride ion penetrability class according to the criteria given in Table 11 below (also given in ASTM C1202).

Table 11: Chloride Ion Penetrability based on charge passed

Sl. No.	Charge Passed (Coulombs)	Permeability Class as per ASTM C1202
1	>4,000	High
2	2,000-4,000	Moderate
3	1,000-2,000	Low

4	100-1000	Very Low
5	<100	Negligible

Fig 3: RCPT Test Apparatus

c. **Test Results:** Test results are discussed under **Table 12.**

Table 12: Results for RCPT Test

Sr. No.	Sample ID	*Charge Passed(Coulombs)
1	CM35 (Control concrete)	397
2	CI35(Concrete with Bipolar Corrosion inhibiting Admixture "CORROSTOP-15")	473

Note: *These test results corresponds to average of three test specimen.

Observation: From test results as shown in table 12, it can be observed that average RCPT value determined in terms of charge passed as coulombs of the concrete mixes, CM 35 (control concrete) and CI 35 (Concrete containing Bipolar corrosion inhibiting admixture i.e.,

"CORROSTOP-15") was found to be in the range of 100-1000 Coulombs. According to ASTM C1202 classification, both values fall within the "very low" chloride ion penetrability range (100–1000 Coulombs)

4.7 Long Term Corrosion Test as per G-109

a. Three concrete specimens (size = 280x150x115mm) each with corrosion inhibiting admixture (at dosage level of 0.50% by weight of cementitious content) & without corrosion inhibiting admixture (i.e., control sample) were cast for M35 grade of concrete. In each of these specimens, three clean reinforcement bars conforming to IS: 1786 of size 375mm length & 12mm dia were placed as per details given in ASTM G-109. After that the samples were moist cured for 28days, conditioning of the samples and alternate wetting & drying cycles (at least 9 cycles) was maintained as per procedure laid down in ASTM G-109.

b. *Testing Procedure*

i. This test generally measures the integrated macrocell charge passed between reinforcing bars embedded inside a concrete prism of 115 x 150 x 280 mm (4.5 x 6 x 11 inches) in size.

ii. The specimen includes one 380-400 mm (15-inch) long, straight reinforcing bar (i.e., the anode) and two straight reinforcing bars of same length (i.e., the cathode).

iii. Diffusion / permeation of chloride ions generally take place during the cyclic wet-dry exposure regime consisting of a 2-week ponding period followed by a 2-week drying period.

iv. During the wet-dry exposure cycles, chlorides from the chloride solution reservoir (placed at the top of the concrete surface) are transported towards the steel reinforcement embedded at a depth of 25mm (1 inch) below the concrete surface.

v. The voltage across the anode and cathode is measured at the end of wetting period in each wet-dry cycle. The macrocell charge passed between the anode and the cathode is then calculated using a trapezoidal rule, as given in the ASTM G109

and the cathode is then calculated using a trapezoidal rule, as given in the ASTM G109

vi. The macrocell current was measured at the beginning of the second week of the ponding using multimeter.

c. **Test results** -Results are discussed under **table 13**.

Table 13. Corrosion (Coulombs) as per ASTM G 109

Week No	Cycle No	Control Specimen		Concrete Specimen Admix with Bipolar Corrosion inhibiting Admixture ("CORROSTOP-15")	
		Avg. Marocell Current (uA) (i_j)	Total Corrosion (coulombs) (TCj)	Avg. Marocell Current (uA) (i_j)	Total Corrosion (coulombs) (TCj)
0	-	0.0000	0.00000	0.0000	0.00000
1	1	0.0133	0.0040	0.0100	0.0030
5	2	0.0133	0.0363	0.0133	0.0312
9	3	0.0233	0.0806	0.0100	0.0595
13	4	0.0533	0.1734	0.0133	0.0877
17	5	0.1033	0.3629	0.0433	0.1562
21	6	0.1400	0.6572	0.0300	0.2449
25	7	0.0900	0.9354	0.0133	0.2974
29	8	0.0667	1.1249	0.0267	0.3457
33	9	0.0633	1.2822	0.0167	0.3982

Total Corrosion (coulombs) is given by following Equation

$$TCj = TC_{j-1} + [(t_j - t_{j-1}) \times (i_j + i_{j-1})/2]$$

Where

TC= Total Corrosion (Coulombs)

t_j = time (in seconds) at which measurement of the marocell current is carried out and

i_j = macrocell current (amps) at time , t_j

Sample Calculation:-

At the end of 5 weeks, the total corrosion in Concrete Specimen Admix with Bipolar Corrosion inhibiting Admixture ("CORROSTOP-15") is

$TC_2 = 0.0877 + [(5-1)*604800*((0.0133+0.0433)/2)*10^{-6}] = 0.1562$ C

Note: Conversion factor from weeks to seconds= 7x24x60x60=60480

Observation: From test results as shown in table 13, it can be observed that the integrated macrocell charge passed in concrete samples with corrosion inhibiting admixture ("CORROSTOP-15") is less as compared to the control concrete sample i.e. without corrosion inhibiting admixture. Hence, it can be concluded on the basis of this test results that on addition of corrosion inhibitor ("CORROSTOP-15"), corrosion rate reduces as compared to control concrete sample without corrosion inhibitor.