Durability Studies (Chloride ION Permeability) of Concrete by Using Different Types of Cements

K Lova Raju[1] Prasadula Sreenu[2]
[1]Assistant Professor [2]PG Student
[1,2]Department of Civil Engineering
[1,2]VITAM College of Engineering, Mindivanipalem(V), Sontyam(P), Anandapuram (M), Visakhapatnam 531173, Andhra Pradesh, India

***Abstract*—** Durability plays major role for any concrete structure. Durability is ability to resist different weathering conditions. Chloride ion permeability in concrete will effect on durability. Durable concrete will retain its original form, quality and serviceability when exposed to environment. In this present work, we have done tests on cement, fine aggregate and coarse aggregate. We have done the mix design as per IS code 10262-2009 for concrete of grade M30. We conducted compressive strength test and rapid chloride ion permeability test on concrete of grade M30 by using different cements like Ordinary Portland Cement, Portland Pozzolana Cement& Portland Slag Cement. We conducted the RCPT to determine the penetration of chloride ions for different ages of concrete like 28days & 60days. From the results, finally we concluded that Portland Slag cement has highest resistance against chloride ion penetration.

Keywords: different types of cement, chloride permeability, RCPT

I. INTRODUCTION

The durability of concrete is one of the most important properties because it is essential that concrete should be capable of withstanding the conditions for which it has been designed throughout the life span of a structure. Lack of durability may be caused by external environmental reasons or internal causes within the concrete itself.

A common method of preventing deterioration is to prevent chlorides from penetrating the structure to the level of the reinforcing steel bar by using relatively impenetrable concrete. The ability of chloride ions to penetrate the concrete must then the known for deign as well as quality control purposes.

Corrosion of steel is the primary cause of deterioration of reinforced concrete. The main reason is the ingress of chlorides from deicing salts or exposure to marine environment. Carbonation is another factor.

Carbonation of concrete is a process by which carbon dioxide from the air penetrates into concrete and reacts with calcium hydroxide to form calcium carbonates. The carbonation of concrete is one of the main reasons for corrosion of reinforcement. Of course, oxygen and moisture are the other components required for corrosion of embedded steel.

Chloride attack is one of the most important aspect for consideration when we deal with the durability of concrete. It is particularly important because it primarily causes corrosion of reinforcement. Chloride can enter the concrete by diffusion from environment.

The rapid chloride permeability is the fastest method used for specifications and quality control purposes. This test is one of the non- destructive test (NDT).This method was useful for determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. The digital LED display indicates the voltage available across the concrete specimen under test.

A commonly used test method for concrete mixture evaluation for chloride penetration in the United States is the "Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration" (ASTM C1202; AASHTO T 277), commonly referred to as the rapid chloride permeability test (RCPT). This test was developed in the 1980s (Whiting 1981; Whiting and Mitchell 1992). The test measures the charge passed through a saturated concrete specimen with the application of an electrical potential. A lower charge passed is assumed to provide an indication of better resistance to penetration of chloride ions. In essence, the test method measures the conductivity of concrete. As originally developed, the intent was to establish a correlation of the charge passed measured by ASTM C1202 with the depth of chloride penetration in the chloride ponding test (AASHTO T 259; ASTM C1543).

II. LITERATURE REVIEW

1) Mohamed and W AHawat (2018) has investigation on durability and strength of self-consolidating concrete (SCC) through development and testing of six binary mixes at fixed water-to-binder (w/b) ratio of 0.36. In each of the six SCC mixes, a different percentage of cement is replaced with fly ash. The development of compressive strength for each of the mixes is assessed by testing samples after 3, 7, and 28 days of curing. Durability of each of the six SCC mixes is assessed by measuring the charge passed in Rapid Chloride Permeability (RCP) test. Charge passed was measured in samples cured for 1, 3, 7, 14,28, and 40 days of curing. All mixes out-performed the control mix in terms of resistance to chloride penetration. Binary mix in which 20% of cement is replaced with fly ash exhibited 28-day strength slightly surpassing the control mix.
2) Hamza et al (2017)presented the performance of concrete to sulfates of various concentrations. Concrete Mixes were prepared with Portland Slag Cement, Portland Sulfate Resisting Cement, Portland Limestone Cement and Ordinary Portland Cement and were subjected to an experimental study. Tests included fresh concrete properties as well as hardened concrete properties. Another set of tests were allocated to chemical resistance to sulfates for several weeks. The outcome of their study revealed that exposure characteristics are highly affected by the selection of the cement type. Recommendations are made for applicators to better select the adequate

cement type when serving in sulfate environment. Ultimately, their study can be a step towards proper selection of cement type in light of the nature of sulfate concentrations encountered.

III. EXPERIMENTAL INVESTIGATIONS

A. Cement

1) OPC Cement

In England there is a place called Portland, there is a presence of heavy amount of lime stone in 1824.From then the cement is manufactured with lime stone and is named as Ordinary Portland Cement. This is a basic type of cement with around 95%of clinker and 5% being gypsum. It comes in 3grades [OPC33, OPC43& OPC43].OPC 43grade means the minimum characteristic strength of concrete should not be less than 43Mpa at 28 days.

S. No.	Description	Test Results
1	Grade used	43
2	Fineness of the cement	5%
3	Standard Consistency	31%
4	Initial setting time	40min
5	Final setting time	480min
6	Specific gravity	3.10
7	Compressive strength	44 N/mm^2

Table 1 Physical Properties of cement

B. PPC Cement

It is a kind of cement which is produced by either grinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions. It gains high tensile strength.

S. No.	Description	Test Results
1	Fineness of the cement	4%
2	Standard Consistency	33%
3	Initial setting time	55min
4	Final setting time	520min
5	Specific gravity	2.92
6	Compressive Strength	41 N/mm^2

Table 2: Physical Properties of cement

C. PSC Cement

This is a kind of blended cement manufactured by either grinding the Portland clinker with gypsum or furnace slag. It is preferred cement for construction of underground raft of buildings in coastal region. Resistance to chloride & sulphate attacks low risk of cracking, minimized shrinkage cracks.

S. No.	Description	Test Results
1	Fineness of the cement	3%
2	Standard Consistency	34%
3	Initial setting time	58min
4	Final setting time	560min
5	Specific gravity	2.96
6	Compressive Strength	40N/mm^2

Table 3: Physical Properties of cement

D. Coarse Aggregate

Material which retained on 4.75 mm size classified as a coarse aggregate. For most works, 20 mm aggregate is suitable. The locally available aggregate having nominal size of 20mm was used. Aggregate of maximum size 10mm conforming to IS 383-1970 was used.

S. No	Description	Test Results
1	Nominal size used	10mm
2	Specific gravity	2.74
3	Water absorption	1.2%

Table 4: Material properties of Coarse Aggregate

E. Fine Aggregate

Fine aggregate is a material such as sand, crushed stones or crushed gravel passing through 4.75 mm size. Locally available sand is used as fine aggregate in the concrete mix.

S. No	Description	Test Results
1	Sand zone	Zone- II
2	Specific gravity	2.70
3	Water absorption	0.8%

Table 5: Material properties of Fine Aggregate

Mix Design for M30 Grade Concrete

Mix Proportions

1) Cement = 392.8 kg/m^3
2) Water = 176.8 kg/m^3
3) Fine aggregate = 997.407 kg/m^3
4) Coarse aggregate = 897.49 kg/m^3
5) Water-cement ratio = 0.45
6) Admixture = 0.8%

Mix proportion for the M30 grade of concrete mix is 1:2.54:2.29

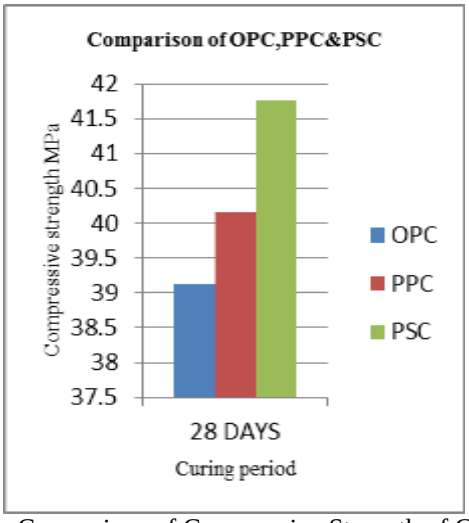
IV. EXPERIMENTAL RESULTS

A. Compressive Strength

Compressive strength test was conducted on concrete cubes of size 150 x 150 x 150 mm cast from concrete of each series, to check quality by obtaining the 28-days compressive strength. The maximum compressive load on the specimen was recorded as the load at which the specimen failed to take any further increase in the load. The compressive strength was calculated by dividing the maximum compressive load by the cross-sectional area of the cube specimen.

S.NO	Type of cement used for concrete cube	28 days
1	OPC	39.13 MPa
2	PPC	40.16 MPa
3	PSC	41.76 MPa

Table 6: Comparison of Compressive Strength of Concrete for OPC, PPC & PSC



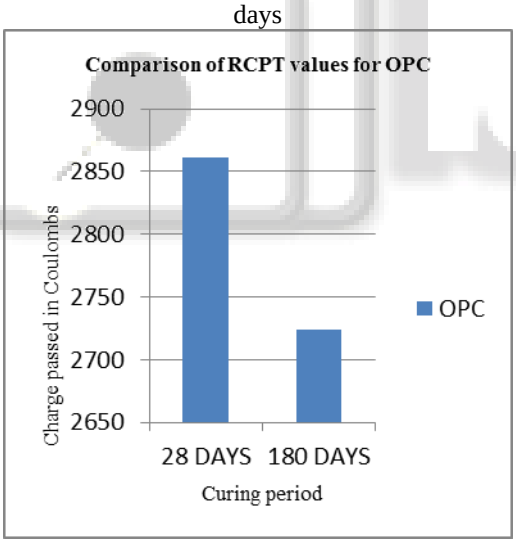
Graph 1: Comparison of Compressive Strength of Concrete for OPC, PPC & PSC

B. RCPT (Rapid Chloride Permeability Test)

The size of specimens 100 mm diameter and 50 mm thick was used. Concrete specimen cylinders are used to determine chloride ion permeability of concrete and were tested as per ASTM C 1202).

S.NO	DAYS	RCPT value	Penetrability
1	28	2860	Moderate
2	180	2724	Moderate

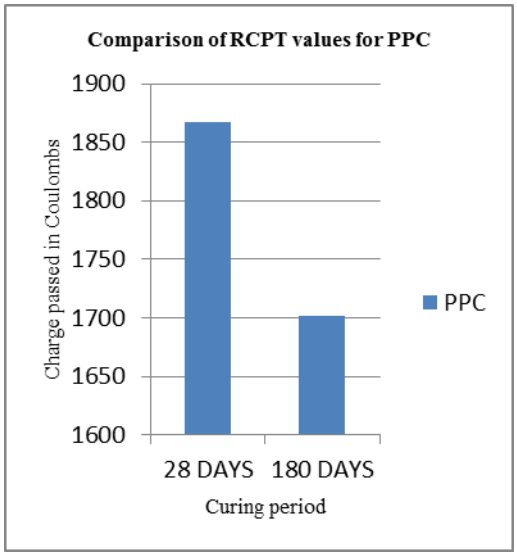
Table 7: Comparison of RCPT values for OPC for 28 & 180 days



Graph 2: Comparison of RCPT values for OPC for 28 & 180 days

S.NO	DAYS	RCPT value	Penetrability
1	28	1867	Low
2	180	1702	Low

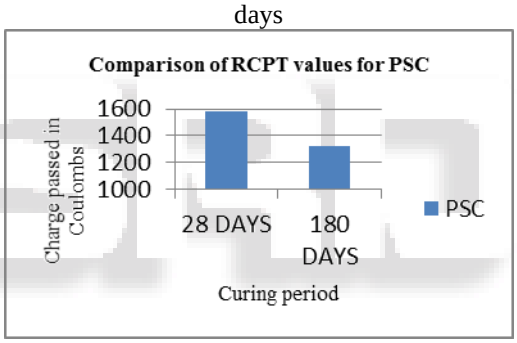
Table 8: Comparison of RCPT values for PPC for 28 & 180 days



Graph 3: Comparison of RCPT values for PPC for 28 & 180 days

S.NO	DAYS	RCPT value	Penetrability
1	28	1577	Low
2	180	1324	Low

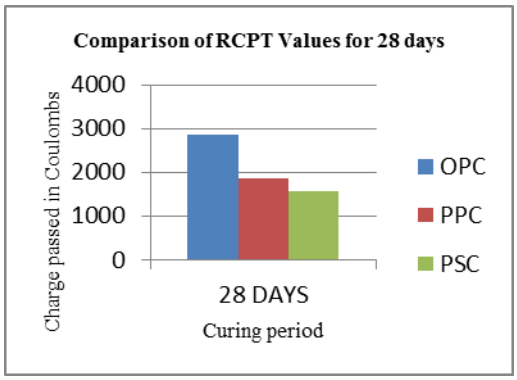
Table 9: Comparison of RCPT values for PSC for 28 & 180 days



Graph 4: Comparison of RCPT values for PSC for 28 & 180 days

S.NO	Type of cement	RCPT value	Penetrability
1	OPC	2860	Moderate
2	PPC	1867	Low
3	PSC	1577	Low

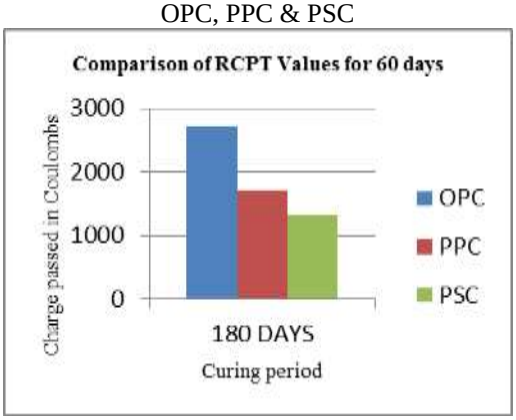
Table 10: Comparison of RCPT values for 28 days for OPC, PPC & PSC



Graph 5: Comparison of RCPT values for 28 days for OPC, PPC & PSC

S.NO	Type of cement	RCPT value	Penetrability
1	OPC	2724	Moderate
2	PPC	1702	Low
3	PSC	1324	Low

Table 11: Comparison of RCPT values for 180 days for OPC, PPC & PSC



Graph 6: Comparison of RCPT values for 180 days for OPC, PPC & PSC

V. DISCUSSION OF RESULTS

1) From the Graph no 1 we observed that the compressive strength of Portland Slag Cement is more comparing with Ordinary Portland Cement and Portland Pozzolana Cement for 28 days.
2) From the Graph no 2 we observed that the charge passed through OPC specimen is low for 60 days curing period when compared for 28 days curing period.
3) From the Graph no 2 we can say that the penetrability range is moderate for OPC for 28 days & 60 days.
4) From the Graph no 3 we observed that the charge passed through PPC specimen is low for 60 days curing period when compared with 28 days curing period.
5) From the Graph no 3 we can say that the penetrability range is low for PPC for 28 days & 60 days.
6) From the Graph no 4 we observed that the charge passed through PSC specimen is low for 60 days curing period when compared with 28 days curing period.
7) From the Graph no 4 we can say that the penetrability range is low for PSC for 28 days & 60 days.
8) From the Graph no 5 we can conclude that the charge passed through PSC specimen is low when compared with OPC and PPC for 28 days.
9) From the Graph no 5 we can say that the penetrability range is low for PSC for 28 days when compared with OPC and PPC for 28 days.
10) From the Graph no 6 we can conclude that the charge passed through PSC specimen is low when compared with OPC and PPC for 60 days.
11) From the Graph no 6 we can say that the penetrability range is low for PSC for 60 days when compared with OPC and PPC for 60 days.

Charge Passed (coulombs)	Chloride Ion Penetrability
> 4,000	High
2,000–4,000	Moderate
1,000–2,000	Low
100–1,000	Very low
< 100	Negligible

VI. CONCLUSION

After completion of total experimental methodology, from the above investigations and from the test results below conclusion are made.

1) The compressive strength of Portland Slag Cement is more comparing with Ordinary Portland Cement and Portland Pozzolana Cement for 28 days.
2) The charge passed through OPC specimen is less for 180 days curing period when compared for 28 days curing period.
3) The penetrability range is moderate for OPC for 28 days to 180 days.
4) The charge passed through PPC specimen is less for 180 days curing period when compared with 28 days curing period.
5) The penetrability range is low for PPC for 28 days to 180 days.
6) The charge passed through PSC specimen is less for 180 days curing period when compared with 28 days curing period.
7) The penetrability range is low for PSC for 28 days to 180 days.
8) The charge passed through PSC specimen is low when compared with OPC and PPC for 28 days.
9) The penetrability range is low for PSC for 28 days when compared with OPC and PPC for 28 days.
10) The charge passed through PSC specimen is low when compared with OPC and PPC for 180 days.
11) The penetrability range is low for PSC when compared with OPC and PPC for 180 days.

REFERENCES

[1] Hamza et al "*THE EFFECT OF CEMENT TYPE ON CONCRETE RESISTANCE TO SULPHATES*", Research Gate, June 2017.
[2] Anna Rose A Javier et al "*COMPRESSIVE STRENGTH AND CHLORIDE PENETRATION TESTS OF CEMENT CONCRETE WITH RICE ASH*".ELSEVIER,2016.
[3] Karthik H. Obla et al "*TESTS AND CRITERIA FOR CONCRETE RESISTANT TO CHLORIDE ION PENETRATION*".ACI Materials Journal 2016.
[4] İsa Yüksel and Ozan Demirtaş*"EFFECT OF NGBFS AND CBA AS FINE AGGREGATE ON THE CHLORIDE PERMEABILITY OF CONCRETE".*American Journal of Engineering Research (AJER) 2013.
[5] Eric William Ryan*"COMPARISON OF TWO METHODS FOR THE ASSESSMENT OF CHLORIDE ION PENETRATION IN CONCRETE".* University of Tennessee, 2011.

[6] Mohammad Iqbal Khan *"CHLORIDE INGRESS RESISTANT CONCRETE: HIGH PERFORMANCE CONCRETE CONTAINING SUPPLEMENTARY COMPOSITES".*International Journal of Civil & Environmental Engineering IJCEE-IJENS, 2010.
[7] V. Sirivivatnanon and R.P. Khatri *"CHARACTERISING CHLORIDE PENETRATION RESISTANCE OF CONCRETE",* 2008.
[8] IS 383-1970 Specifications for Coarse and Fine aggregate.
[9] IS:4031(part-11)-1988 Test procedure for specific gravity of cement
[10] IS: 4031(part-11)-1996 Test procedure for fineness of cement
[11] IS:4031(Part-4)-1988 Test procedure for normal consistency of cement
[12] IS:4031(Part-5)-1988 Test procedure for initial and final setting time of cement
[13] IS:4031(part-6)-1988 Test procedure for compressive strength of cement
[14] IS:2386(part III) -1963 Test procedure for specific gravity of coarse aggregate and water absorption of coarse aggregate

