# AN EXPERIMENTAL INVESTIGATION ON DURABILITY STUDIES OF CONCRETE BY USING DIFFERENT TYPES OF CEMENTS (OPC, PPC & PSC)

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**Abstract -** *In this present investigation, the durability studies of concrete were determined. The cements like OPC, PPC and PSC was used to make the concrete. The physical property such as fineness, setting time, specific gravity etc for cement and fineness modulus, water absorption etc for aggregates was calculated. Mix design for normal concrete M30 was calculated based on trial mixes and code IS: 10262-2009. The compressive strength of concrete was calculated for M30 concrete by using OPC, PPC and PSC at 7, 28, 60, 90 and 120 days. The curing of specimens can be done after casting in normal water, sea water, acid attack and sulphate attack. Finally we were compared all the results and concluded that PSC (Portland slag cement) was gave better durability results to compare with other cements.*

***Key Words***: **OPC, PPC, PSC, Concrete, Durability, Strengths.**

## 1. Introduction

Concrete is one of the building materials used in modern construction, because of its durability to cost ratio. As we know that concrete which is made by mixing cement, water, fine and coarse aggregate and sometimes admixture in their right proportion is major construction material. When these ingredients are mixed together, they form a fluid mass that is easily moulded into any shape. Over time, the cement forms a hard matrix which binds the ingredients together into a durable stone-like material with many uses. Different types of cement are manufactured to meet different physical and chemical requirements for specific purposes. Durability is defined as the capability of concrete to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties. It normally refers to the duration or life span of trouble-free performance.

## 2. Literature Review

**P.M.Hoby et al (2017)** presented the performance of multi blended cement concrete in marine environment. This paper aims to consolidate the studies conducted on the performance of blended concrete with Supplementary Cementing Materials (SCM) in Marine environment and compare with an experimental analysis. The main impact of supplementary cementing material is the reduced chloride intrusion thereby reduction in reinforced corrosion. In this study, an attempt has been made to identify different experimental methods used to analyse the performance of multi-blended concrete exposed to marine environment and to review different methodologies adopted for the accelerated corrosion studies. The ternary blended concrete exhibits very good corrosion resistance properties with a nominal reduction in compressive and split tensile strength.

**Seung-jun kwon et al (2017)** has investigation on long- term corrosion performance of blended cement concrete in the marine environment. This paper presents the long term corrosion performance of blended cements namely Portland pozzolana cement (PPC) and Portland slag cement (PSC) concrete under the three marine exposure conditions such as, atmospheric zone (AZ), immersion zone (IZ) and Splash zone (SZ). The concrete cubes were exposed over the period of 10 years and their physicochemical properties were carried out and the results obtained were compared with Ordinary Portland Cement (OPC) concrete. It was observed that the strength and alkalinity of the blended cement concretes were relatively equal to that of OPC concrete. In addition, the pH values of the blended cement concretes are above the threshold limit recommended for depassivation. From the results it is observed that the blended cement concretes are technically viable from the durability point of view and highly recommended for aggressive marine environments rather than OPC concrete.

**G.V. Ramana et al (2016),** In this research an attempt is made to compare the performance of multi blended mix concretes i.e. both binary and ternary mixes with ordinary Portland cement (OPC) concrete. In binary mixes cement was partially replaced by low calcium fly ash (LCFA) or silica fume (SF) and in ternary mixes both LCFA and SF were combined to partially replace OPC. The class F fly ash is used in different proportions of 20%, 30%and 40% and silica fume of 5% and 10% by weight of cement. A constant water binder ratio of 0.42 was maintained. Super plasticizer of required quantity was added to achieve the required degree of workability. The specimens were tested for compression as well as UPV at different ages 7, 28, 56 & 91 days and also the same were subjected to electrical resistance, chloride permeability (ASTM C1202 RCPT test) and under water abrasion (UWA) at both 28 and 91 days. It can be concluded that it is possible to develop ternary mix normal strength concrete

better than OPC concrete especially with reference to performance in terms of durability. Within the limits of the experimental investigation it is concluded that the ternary mix consisting of combination of 5% SF and LCFA up to 30% demonstrated high performance.

**3. Experimental Program**

**3.1 Materials Used**

**A) Ordinary Portland cement**

Ordinary Portland cement of (53 Grade) with consistency confirming to IS 12269-1987 was used. The results of tests conducted on cement are presented in table along with the permissible limits for ascertaining quality of cement.

Table 1 Result for OPC

| PROPERTIES | RESULTS | AS PER IS CODE PROVISIONS |
|---|---|---|
| Fineness | 92 % | 90 % |
| Specific gravity | 3.07 | 3.15 |
| Normal consistency | 31 % | 28 – 35 % |
| Initial setting time | 40 Minutes | >30 Minutes |
| Final setting time | 480 Minutes | <600 Minutes( 10 Hours) |

**B) Portland Pozzolana cement**

Portland Pozzolana cement of (53 Grade) with consistency confirming to IS 1489 (Part - 1) 1991 (fly ash based), IS 1489 (Part - ll) 1991(canalized clay) was used. The results of tests conducted on Cement are presented in table along with the permissible limits for ascertaining quality of cement.

Table 2 Results for PPC

| PROPERTIES | RESULTS |
|---|---|
| Fineness | 94 % |
| Specific gravity | 2.47 |
| Normal consistency | 35 % |
| Initial setting time | 55 Minutes |
| Final setting time | 520 Minutes |

**C) Portland slag cement**

Portland slag cement of with consistency confirming to IS 455:1987 was used. The results of tests conducted on cement are presented in table along with the permissible limits for ascertaining quality of cement.

Table 3 Results for PSC

| PROPERTIES | RESULTS |
|---|---|
| Fineness | 93 % |
| Specific gravity | 3.2 |
| Normal consistency | 33 % |
| Initial setting time | 52 Minutes |
| Final setting time | 540 Minutes |

**D) Fine Aggregate**

Natural River sand of size below 4.75mm conforming to zone ll of IS 383-1970 is used as fine aggregate.

Table 4 Results for FA

| Physical Properties | Natural Fine Aggregate | As per IS code provision |
|---|---|---|
| Specific gravity | 2.64 | IS 383 – 1970 |
| Sieve Analysis | Zone ll | IS 383 – 1970 |
| Water absorption | 0.8 % | IS 383 – 1970 |

**E) Course aggregate**

Coarse aggregate consists of river gravel, crushed stone or manufactured aggregate with particle size equal to or greater than 4.75mm.And having density of 2700kg/$m^3$ It shall comply with the requirements of IS383-1970. For the coarse aggregates, the following test has been carried out conforming to IS2386 (part 1) 1963. In this study coarse aggregate of maximum nominal size 20 mm was used and the physical properties are as follows.

Table 5 Results for CA

| Sl. No | Property | Results | AS PER IS CODE PROVISIONS |
|---|---|---|---|
| 1 | Specific gravity | 2.74 | IS 383 – 1970 |
| 3 | Water absorption | 1.2% | IS 383 – 1970 |

**3.2 Mix Design**

M30 grade concrete mix design was carried out as per IS 10262-2009 and IS 456-2000.

Table 6 Mix proportions

| Sl. No | Material | per $m^3$ |
|---|---|---|
| 1 | Cement | 350 kg |
| 2 | Fine Aggregate | 709 kg |
| 3 | Coarse Aggregate | 1220 kg |
| 4 | Water | 157 liters |
| 5 | W/C ratio | 0.45 |

### 3.3 Potable Water

Ordinary potable tap water available in laboratory was used for mixing and curing of reference concrete. It had a pH value of 7.1.

### 3.4 Preparation of Specimens

The ingredients for various mixes were weighed; required water was added and mixed by using a tilting drum type concrete mixture machine. Precautions were taken to ensure uniform mixing of ingredients. The specimens were cast in steel mould and compacted on a table vibrator. The specimens of 150mm× 150mm × 150mm size of cubes for compression strength were cast as per Indian standard IS:516 (1959). Specimens were de-moulded in 24 hours and cured.

### 3.5 Curing

**Normal Water Curing**

After demoulding, the specimens were kept in normal water curing having pH value of 7.1.

**Sea Water Curing**

After demoulding, the specimens were kept in sea water curing having pH value of 6.5 taken from bheemili beach, Visakhapatnam.

**Acid Attack**

After demoulding, the specimens were kept for acid attack. For acid attack, 5% dilute Hydrochloric Acid (HCl) with pH value of about 1 was used.

**Sulphate Attack**

After demoulding, the specimens were kept for Sulphate attack. For alkaline attack test, a solution containing five percent of sodium sulphate (Na2SO4) and five percent of magnesium sulphate (MgSO4) by weight of water with pH value of about 10 was used.

## 4. Test Results and Discussion

**Normal Water curing**

Table 7 compressive strength ($N/mm^2$) NWC

| CEMENT | 7 DAYS | 28 DAYS | 60 DAYS | 90 DAYS | 120 DAYS |
|---|---|---|---|---|---|
| OPC | 24.82 | 37.28 | 37.34 | 37.34 | 37.36 |
| PPC | 25.12 | 38.26 | 38.36 | 38.38 | 38.4 |
| PSC | 26.08 | 38.86 | 38.9 | 38.92 | 38.92 |

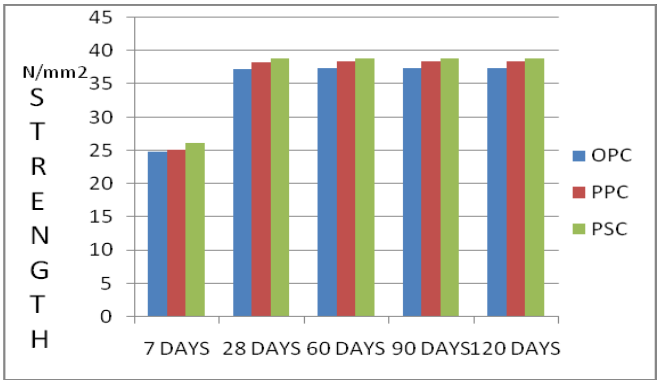


Chart 1 compressive strength (Normal water curing)

For normal water curing, the compressive strength of concrete was increased with time and Portland slag cement was given more strength to compare with other two cements.

**Sea water curing**

Table 8 compressive strength ($N/mm^2$) SWC

| CEMENT | 7 DAYS | 28 DAYS | 60 DAYS | 90 DAYS | 120 DAYS |
|---|---|---|---|---|---|
| OPC | 23.86 | 36.26 | 36.28 | 36.24 | 36.24 |
| PPC | 24.69 | 37.64 | 37.64 | 37.58 | 37.56 |
| PSC | 25.64 | 37.92 | 37.94 | 37.9 | 37.88 |

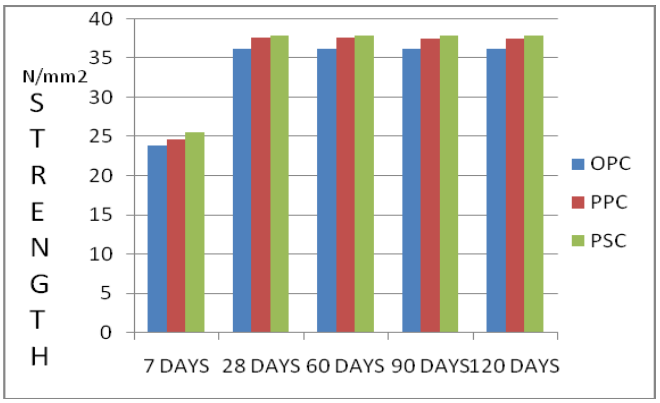


Chart 2 compressive strength (Sea water curing)

For Sea water curing, the compressive strength of concrete was increased with time upto 60 days later it was decreased. Portland slag cement was given more strength to compare with other two cements. The overall result compare with normal water curing, the sea water results was less.

**Acid attack**

Table 9 compressive strength ($N/mm^2$) AA

| CEMENT | 7 DAYS | 28 DAYS | 60 DAYS | 90 DAYS | 120 DAYS |
|---|---|---|---|---|---|
| OPC | 20.21 | 32.56 | 32.48 | 32.44 | 32.42 |
| PPC | 21.88 | 34.12 | 34.06 | 34.04 | 34.02 |
| PSC | 23.62 | 35.72 | 35.7 | 35.68 | 35.68 |

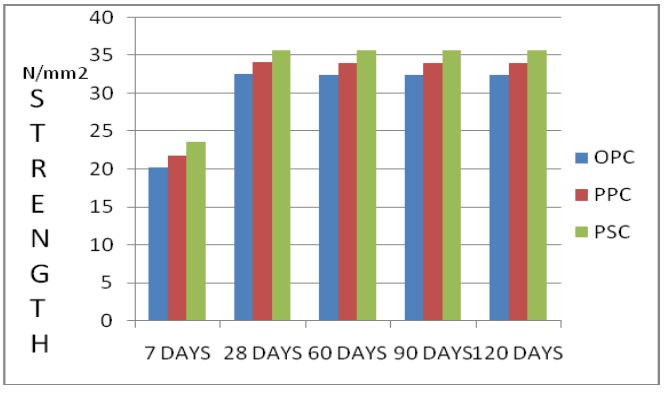


Chart 3 compressive strength (Acid Attack)

For Acid Attack, the compressive strength of concrete was increased with time upto 28 days and later the strength was decreased with time. Portland slag cement was given more strength to compare with other two cements. The overall result compare with normal water & sea water curing, the acid attack results was less.

**Sulphate attack**

Table 10 compressive strength ($N/mm^2$) SA

| CEMENT | 7 DAYS | 28 DAYS | 60 DAYS | 90 DAYS | 120 DAYS |
|---|---|---|---|---|---|
| OPC | 23.24 | 34.98 | 34.94 | 34.92 | 34.9 |
| PPC | 24.36 | 35.82 | 35.76 | 35.76 | 35.74 |
| PSC | 25.14 | 36.88 | 36.82 | 36.8 | 36.8 |

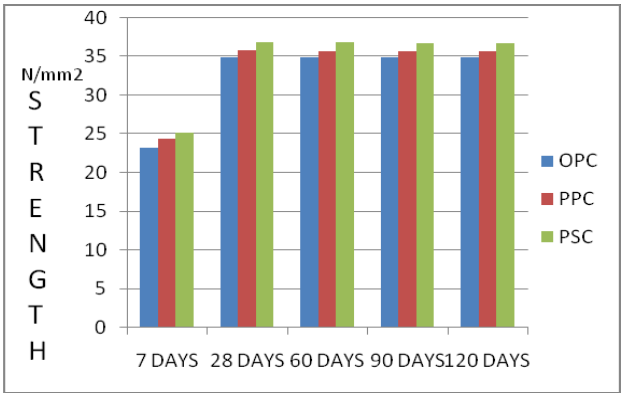


Chart 4 compressive strength (Sulphate attack)

For Sulphate Attack, the compressive strength of concrete was increased with time upto 28 days and later the strength was decreased with time. Portland slag cement was given more strength to compare with other two cements. The overall result compare with normal water & sea water curing, the sulphate attack results was less. The overall result compare with acid attack, the sulphate attack results was more.

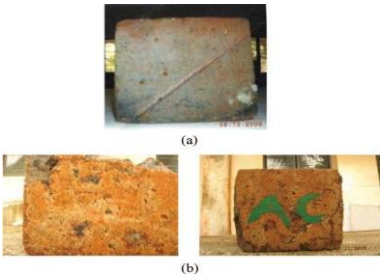


Fig 1 Sulpahte attack(a) and Acid attack(b) of cubes

**5. CONCLUSIONS**

For normal water curing the strength was increased with time for all three types of cement. Portland slag cement was given more strength 38.92 for 120 days to compare with OPC and PPC.

For Sea water curing the strength was increased with time upto 60 days later it was decreased for all three types of cement but it was low to compare with the normal water curing results. Portland slag cement was given more strength 37.94 for 60 days to compare with OPC and PPC.

For Acid Attack, the compressive strength of concrete was increased with time upto 28 days and later the strength was decreased with time. Portland slag cement was given more strength 35.72 at 28 days to compare with other two cements. The overall result compare with normal water & sea water curing, the acid attack results was less.

For Sulphate Attack, the compressive strength of concrete was increased with time upto 28 days and later the strength was decreased with time. Portland slag cement was given more strength 36.88 at 28 days to compare with other two cements. The overall result compare with normal water & sea water curing, the sulphate attack results was less. The overall result compare with acid attack, the sulphate attack results was more.

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