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STRENGTH AND DURABILITY STUDY ON CONCRETE USING DIFFERENT TYPES OF BINDERS (OPC & PPC)

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Abstract - *This paper reports the strength and durability behaviour of concrete made with different types of binders such as OPC & PPC. Portland Pozzolana Cement (PPC) is a kind of Blended Cement which is produced by either intergrinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions. In this paper, the concrete of grade M 30 was used and tested for various mechanical properties such as compressive strength, split tensile strength and flexural strength, durability properties such as salt resistance, sulphate resistance and acid resistance. The test results were arrived and discussed elaborately. It has been noticed that concrete made of PPC binder demonstrates satisfied mechanical and durability properties when compared to conventional concrete. Furthermore, the results proved that PPC binder can be effectively used in construction as a replacement of OPC for sustainable development.*

Key Words: Ordinary Portland Cement, Portland Pozzolana Cement, binder, strength, durability.

1. INTRODUCTION

In the modern construction, concrete is one of the most important building materials because of its strength and durability to cost ratio. Concrete, usually Portland cement concrete, is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens over time most frequently a lime-based cement binder, such as Portland cement, but sometimes with other hydraulic cements, such as a calcium aluminate cement. It is distinguished from other non-cementitious types of concrete, all binding some form of aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concretes that use polymers as a binder. 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.

Jamkar et al. (2013) found that the fly ash fineness plays a vital role in the durability property also the author noticed that increase in the fineness increased both workability and compressive strength. It was also observed that finer particles resulted in increasing the rate of reaction needing less heating time to achieve a given strength [1]. Abdullah Anwar et.al (2014) represented that the optimal percentage for replacement of cement with cementitious material would lead to the production of carbon dioxide and solving the environmental pollution by cement production there by enhances the urban surroundings [2]. R.Bansal et al. (2015) studied that the replacement is of fly ash with cement having been studied for partial replacement of fly ash with cement at 10%, 20%, 30%. It was observed that 10% replacement of fly ash was 20% and 50% decrease the compressive strength at the age of 7 and 28 days respectively. In 20% replacement, 7% and 11% increase of compressive strength was observed at the age of 7 and 28 days respectively. In 30% replacement 23% and 19% increase the compressive strength was observed at the age of 7and 28 days respectively [3]. Siddique (2003) investigated that fly ash replacing fine aggregate shows increase in strength. It has been also noticed that the rate of increase of strength decreases with increase in fly ash content. At 50% replacements of fine aggregate by fly ash, compressive strength of concrete increased by 51.5% and 67.1% at 28 and 365 days respectively [4]. Elango & his associate (2016) investigated that Pozzalona cement (PPC) binder using different aggregate sizes. PPC is not new to the world and is a better alternative to OPC as it gives better performance of concrete in terms of strength and durability. Moreover, it helps in disposing fly ash and conserves mineral resources in the sense that lesser amount of limestone is used. The compressive strength split tensile strength and flexural strength of PPC mix specimens are slightly lesser than OPC mix specimens due to less heat of hydration [5].

Elango & his associate (2017) found that Portland Pozzolana Cement is a kind of blended cement which is produced by either inter grinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions. Pozzolana is a natural or artificial material containing silica in a reactive form [6]. Maheswaran et al. (2018) studied that PPC mix specimens shows higher porosity and permeability when compared to conventional control mix, whereas the density values are vice versa. This is because, greater the porosity reduces the density of the mix. PC mix specimens shows better resistance against chemical solution because pozzolanic material present in PPC results in pore refinement [7].

2. MATERIALS

2.1 Cement

The Ordinary Portland Cement (OPC) of 53 grade conforming to IS 12269 - 2013 and Portland Pozzolana Cement conforming to IS: 1489 (1) -1991 used in this study was procured from the local market. The physical property tests were carried out as per IS 4031-1988 (Reaffirmed 2014) and the experimental results are given in Table 1.

Table -1: Physical properties of Cement

S.No	Test conducted	Experimental Results (OPC)	Experimental Results (PPC)
1	Specific gravity	3.13	2.95
2	Fineness	92	95
3	Consistency (%)	31	34
4	Initial setting time	32 min	50 min
5	Final setting time	286 min	125 min

2.2 Fine aggregate

Manufactured sand (M-sand) is used as a fine aggregate and it was procured from local quarry. Tests for fine aggregate was carried out in the laboratory as per IS 383-1970 (Reaffirmed 2011) and presented in Table 2. The fine aggregate used in this project belongs to grading zone II and fall under the category of medium sand.

Table -2: Physical properties of Fine aggregate

S.No	Test conducted	Experimental Results
1	Specific gravity	2.56
2	Fineness modulus	2.76

2.3 Coarse aggregate

Crushed blue granite metal (coarse aggregate) of size 20 mm used in the present work was collected from local quarry. Physical property tests were carried out in accordance with IS 2386-1963 (Reaffirmed 2011) and presented in Table 3.

Table -3: Physical properties of Coarse aggregate

S.No	Test conducted	Experimental Results
1	Specific gravity	2.8
2	Water absorption value (%)	1.2
3	Impact value (%)	8.50
4	Crushing value (%)	23.65
5	Abrasion value (%)	25.50

2.4 Water

Mixing water used in the study satisfied the quality standards of drinking water and it was taken from KPR Institute of Engineering and Technology, Coimbatore, Tamilnadu.

2.5 Mix proportion

The concrete mix design was performed according to IS 10262: 2009. M 30 grade of concrete mix design was carried out and the quantity of materials arrived are presented in Table 4.

Table -4: Mix proportion

S.No	Materials	kg/m^3
1	Cement	448
2	Fine aggregate	635
3	Coarse aggregate	1041
4	Water	197
5	W/C ratio	0.45

3. EXPERIMENTAL PROGRAM

To determine the mechanical properties of the concrete, tests such as compressive strength test, split tensile test and flexural test were carried out. Moreover 12 numbers of cube specimen of size 150 mm x 150 mm x 150 mm, Cylinder specimen size of 150 mm dia. and 300 mm height, prism specimen of size 100 mm x 100 mm x 500 mm were casted and tested for 7 days and 28 days. Furthermore 18 numbers of cube specimens were casted to study the durability properties such as salt resistance, sulphate resistance and acid resistance test. Sodium Chloride (NaCl) was used to study the salt resistance of the specimens. Hydrochloric acid (HCl) and Magnesium Sulphate ($MgSO_4$) was used for acid and sulphate attack study.

4. RESULTS AND DISCUSSION

4.1 Mechanical Properties

Compressive strength, split tensile strength and flexural strength test results of OPC and PPC binder concrete are presented in Table 5 and graphically represented in Chart 1-3.

Table -5: Mechanical properties of various binders

Age of test (days)	Compressive strength (MPa)		Split tensile strength (MPa)		Flexural strength (MPa)	
	OPC	PPC	OPC	PPC	OPC	PPC
7	24.26	22.25	2.52	2.15	3.84	3.30
28	39.87	35.35	4.16	3.35	4.51	4.12

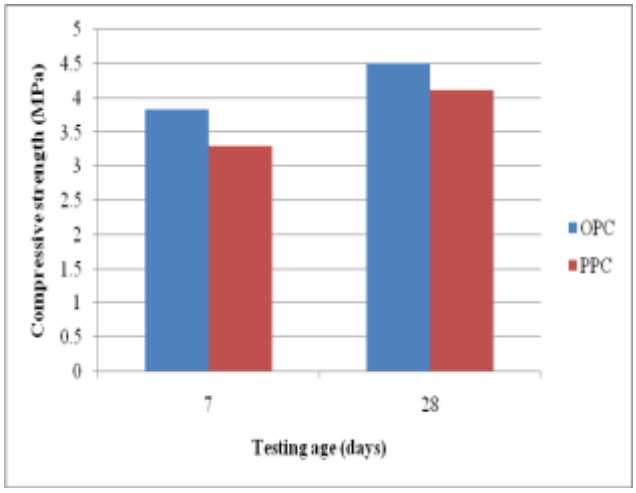

Chart-1: Compressive strength

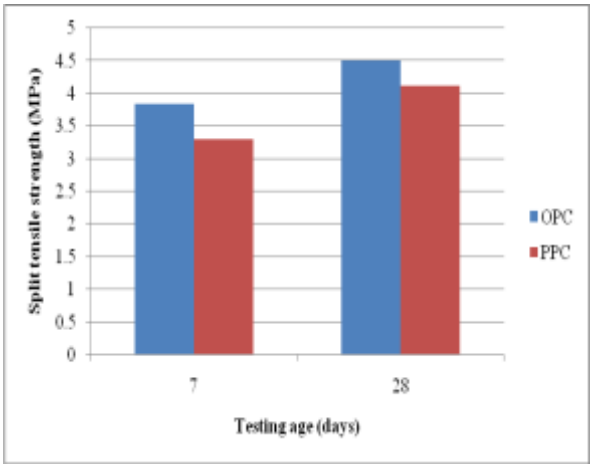

Chart- 2: Split tensile strength

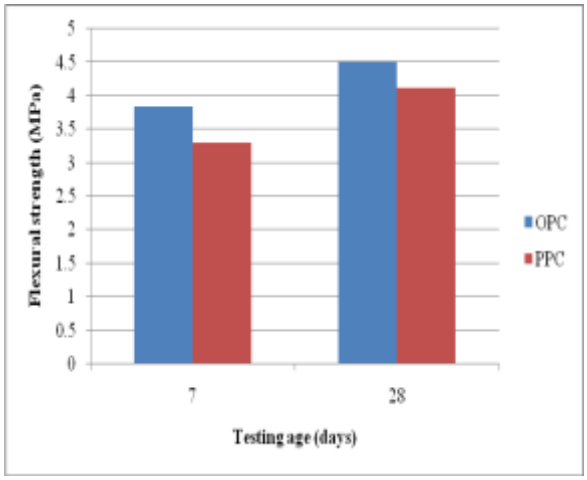

Chart.-3: Flexural strength

The test results indicated that, at the age of 28 days mix made with PPC exhibited 11.3% lesser compressive strength than conventional control mix OPC. Similarly, 19.4% lesser split tensile strength was noticed in PPC mix than OPC. Regardless of flexural strength, PPC mix has demonstrated 8.6% lesser flexural strength than conventional control mix OPC. This can be attributed to the fact that pozzolanic material present in PPC would lead to less heat of hydration that result in lesser strength gain at earlier ages.

4.2 Durability properties

Table 6 shows the effect of weight loss and loss in strength of OPC and PPC mix immersed in sodium chloride (NaCl), magnesium sulphate ($MgSO_4$) and Hydrochloric acid (HCl) solution in at the age of 56 days. Test results shows that OPC and PPC specimens shows better resistance against chemical attack. Furthermore, visual observation reveals that minor physical deterioration has occurred at the edges for the specimens immersed in $MgSO_4$ and HCl solution. Regardless of colour change slight whitish formation was appeared on the surface of the specimens immersed in $MgSO_4$ solution due to the displaced calcium precipitates mainly as gypsum. Specimens immersed in acid solution exhibits solution exhibits slight reddish colour formation on the surface due to the presence of iron content (Fe_2O_3) in fly ash and presence of free lime and iron content in the hydrated cement matrix. Specimens subjected to chemical attack are shown in Fig 1.

Fig.-1: Specimens subjected to chemical attack

Table -6: Durability properties of various binders

Tests conducted	Weight loss (%)		Strength loss (%)	
	OPC	PPC	OPC	PPC
Salt attack	0.71	0.65	4.27	3.25
Sulphate attack	0.82	0.72	4.49	4.05
Acid attack	1.21	1.05	5.20	4.65

5. CONCLUSIONS

Mechanical properties such as compressive strength, split tensile strength, flexural strength, durability properties such as salt resistance, sulphate resistance and acid resistance were found and based on the test results the following conclusions can be drawn.

1) Compressive strength, split tensile strength and flexural strength of PPC mix specimens are slightly lesser than OPC mix specimens due to less heat of hydration.

2) PPC mix specimens showed better resistance against chemical solution because pozzolanic material present in PPC results in pore refinement.

3) Specimens immersed in MgSO4 solution have demonstrated whitish formation because of displaced calcium precipitates mainly as gypsum. Similarly, specimens immersed in acid solution exhibits solution slight reddish colour formation on the surface due to the presence of iron content (Fe_2O_3) in fly ash and presence of free lime and iron content in the hydrated cement matrix

4) Concrete made with PPC as binder satisfies the strength and durability requirements with adequate properties and it can be used for sustainable construction.

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