http://dx.doi.org/10.21172/ijiet.201.04

Influence of Controlled Acidic Environmenton Portland Slag Cement Concrete

Venkata Rambabu V[1], Amit B Mahindrakar[2]
[1]*Assistant Professor, Dept. of Civil Engineering, N.B.K.R.I.S.T*
[2] *Professor, SCALE, VIT University, Vellore*

Abstract - Ordinary Portland cements can be blended with pozzolanic materials like ground granulated blast furnace slag (GGBFS), to make the structures long lasting and durable. GGBFS helps in secondary hydration, producing more C-S-H gel in the system for better performance of concrete. Pore refinement and grain refinement caused by secondary hydration increase the impermeability of concrete,making it more durable. Due to this additional advantage of Portland slag cement (PSC) over ordinary Portland cement, in the present study, M_{30} grade concrete is prepared with PSC. The concrete specimens were cured in normal potable water for a period of 28days and later in 5%concentration hydrochloric acid for a period of another 150 days. The concrete specimens were tested for their strength properties like compressive strength and split tensile strength, durability properties like water absorption and weight loss. An attempt has been made to study the microstructural properties by using Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDAX) and X-ray Diffraction (XRD). The SEM analysis indicated an enhanced pore refinement. The EDAX analysis showed an increase in the calcium carbonate phase after 28 days, as a layer over silica. The phase identification analysis revealed the presence of calcium carbonate, silica and also their reaction product, calcium silicate.

Key words: Ground granulated blast furnace slag, Portland slag cement, SEM, EDAX, XRD.

I. INTRODUCTION

Concrete is used for many applications, including basic foundations, superstructures, wastewater treatment facilities, water treatment facilities, parking structures, floor construction, and exterior surfaces. Along with concrete, the form systems has evolved to allow for more efficient placement, large quantity placement, and architectural finish features that may be desired. Over the above the significance of concrete is getting increased over past two decades.

Until recent years, the overwhelming focus has been on concrete's compressive strength, which has been mainly related to the overall porosity of the cement paste matrix and the amount and structure of the aggregates. Mechanical strength depends on defects and not on any overall average property, and so is very difficult to relate to microstructure. This has caused relatively little attention to be paid to the details of the pore space. Unfortunately, it has perhaps led to the idea that concrete is simply a commodity material, with nothing needed to be understood about the microstructure. However, more recently, it has been recognized that much of the concrete in the infrastructure in the U.S. and Europe and elsewhere has been deteriorating faster than expected, with much of this deterioration due to the corrosion of reinforcing steel coming from the ingress of chloride and other ions from road salts, marine environments, and ground soils. Hence close attention is now being paid to the transport properties of concrete (diffusivity, permeability, sorptivity, etc.) which, although still difficult to relate to pore structure and microstructure, are easier to study in a fundamental way than is compressive strength. This has led to new attention being paid to the microstructure of concrete, with the realization that concrete is a complex composite, whose improvement and control require the usual materials science approach of processing, microstructure, and properties.

Pengfei Huanget.al.,(2005), prepared test samples that were cured for 360 days were exposed in an aggressive environment (with 5%, 10%, 15%, and 20% HCl content, respectively) for 24 h. The mass loss, the dynamic modulus loss, the flexural strength, and the compressive strength were measured using a series of the etched samples. The results indicate that the mechanical properties of concrete were degraded with the increasing HCl content of the corrosion medium.

GiriPrasad.Get.al.,(2009), prepared M60 grade concrete specimens and immersed in sulphuric acid (H_2SO_4) and Hydrochloric acid (H Cl) solutions.The parameters investigated are percentage weight loss, Acid

Durability Factor (ADF) and Acid Attack Factor (AAF) per face in 2% and 5% concentration solutions of H_2SO_4 and H Cl. The results indicate an increase in percentage weight loss.

II. EXPERIMENTAL PROCEDURE

7.5cm diameter and 15cm height cylinders were prepared using Portland slag cement under seven different cases. 1. Concrete without reinforcement and without admixture, 2.Concrete without reinforcement and with calcium nitrate, 3. Concrete without reinforcement and with Commercial admixture, 4 .Concrete with reinforcement and without admixture, 5. Concrete with reinforcement and with calcium nitrate), 6. Concrete with reinforcement and with Commercial admixture and, 7. Concrete with reinforcement and epoxy coating on reinforcement.

A concrete mix was designed to get M_{30} grade concrete according IS: 10262-2009 with design proportion 1: 1.50: 2.34. The specimens were cured in locally available potable water for a period of 28 days later the specimens were cured in 5% concentrated hydrochloric acid for a period of another 150 days. The experiment was carried out in two stages, stage -1period of observation 0 to 28 days with a period of interval of 7days and stage-2 period of observation 28 to 178 days with a period of interval 30days by casting 3replica for each. The SEM, EDAX and XRD test were carried out on powder samples at the end of 28 days and 178 days curing.

Fig-1: Curing of specimens in 5% concentrated HCl

III. TESTS CARRIED OUT

To evaluate strength properties compressive strength test was conducted on specimens without reinforcement (Case-1, Case-2 and Case-3), Split tensile strength tests werecarried out on specimens with reinforcement (case 4 to 7), and to evaluate durability properties weight loss and water absorption of each specimen were calculated. Along with above tests Scanning Electron Microscope (SEM), EDAX analysis and X-Ray Diffraction (XRD) tests were carried out.

IV. RESULTS AND DISCUSSION

4.1 Compressive strength

The compressive strength results of all specimens were tabulated as below.

Table-1 Consolidate table showing compressive strength

Cases	7 days	14 days	21 days	28 days	58 days	88 days	118 Days	148 days	178 days
Case-1	13.92	20.48	22.77	30.55	28.45	23.02	22.04	20.89	20.78
Case-2	13.43	19.33	20.31	30.63	24.41	24.25	23.88	22.98	21.27
Case-3	13.92	13.6	20.48	30.52	23.75	20.81	20.44	20.32	20.12
Case-4	8.83	23.87	30.25	30.86	27.79	23.87	22.94	22.22	21.53
Case-5	9.88	23.47	27.6	30.02	28.83	26.16	25.24	24.88	23.22
Case-6	10.24	21.69	26.67	30.23	27.03	26.45	25.45	25.12	24.32
Case-7	17.52	27.94	29.62	30.58	27.25	22.22	21.22	20.93	20.35

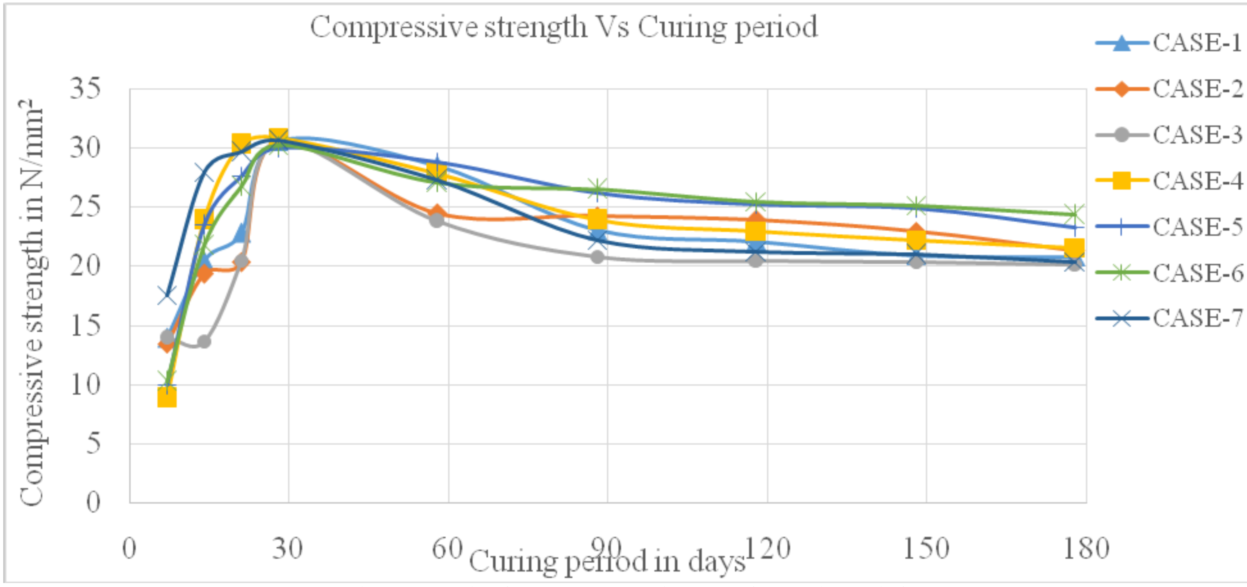


Fig-2: comparisonbetween compressive strength vs curing period

At an age of 28days all specimens achieved target strength of 30 N/mm^2. Concrete specimens made with reinforcement and blended with commercial available admixture shows lowest strength loss around 20% at an age of 178days due to presence of chemical admixture whereas concrete specimens made without any admixture and reinforcement coated with epoxy base resin shows highest loss of strength around 34% was observed. This is due to loss of bond between reinforcing steel and concrete surface.

4.2 Weight loss

The weight loss of each specimen at various intervals of time was tabulated as shown in table-2.

Table-2 Consolidate table showing percentage of weight loss

Cases	7 days	14 days	21 days	28 days	58 days	88 days	118 Days	148 days	178 days
Case-1	-1.23	-1.51	-1.33	-0.07	1.39	-0.23	0.05	1.52	3.45
Case-2	-1.18	-1.49	-1.27	-2.20	-0.11	0.39	0.48	2.34	4.45
Case-3	-1.30	-1.61	-1.23	-1.12	-0.52	-0.58	0.03	1.67	3.68
Case-4	-1.25	-1.32	-1.16	-1.39	-0.26	-0.28	0.01	1.42	3.44
Case-5	-0.17	-0.13	-0.15	-1.04	-0.68	-0.60	0.01	1.34	4.37
Case-6	-1.25	-1.29	-0.99	-2.32	-0.42	0.14	0.44	2.44	4.42
Case-7	-0.31	-1.00	-1.14	-0.04	0.07	0.43	0.64	1.92	4.14

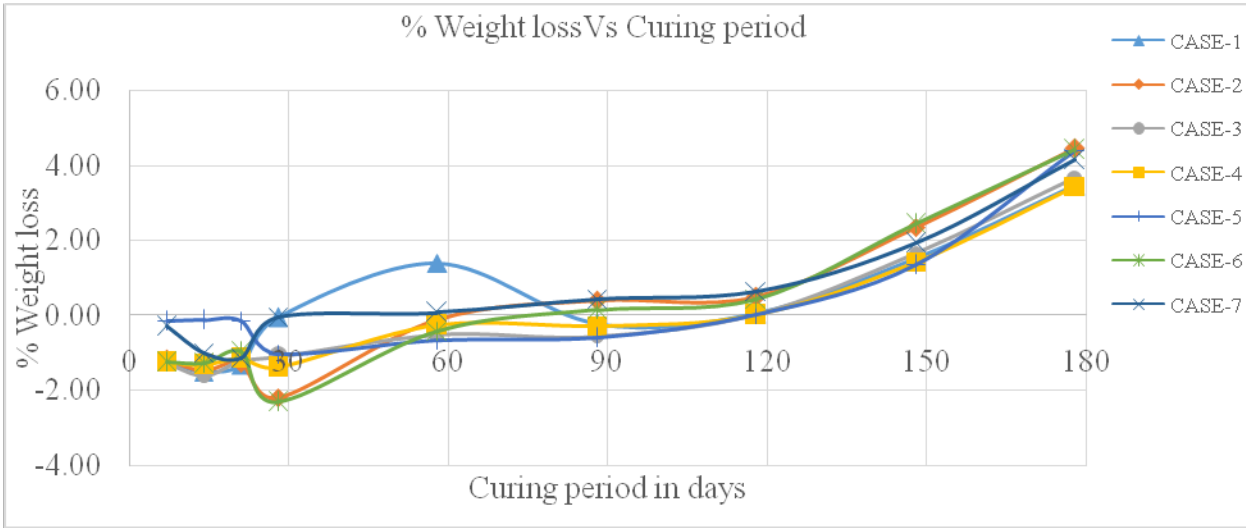


Fig-3: comparison between % weight loss vs curing period

All Specimens shows weight gain up to a curing period of 28days due to chemical reaction between cement and other ingredients, C-S-H gel formation leads to weight gain by filling the pores between the aggregates. The specimens made without any admixture shows less percentage of weight loss around 3.45% and whereas the specimen made with admixture show a high weight loss percentage 4.45% this shows by using admixtures without altering water-cement ratio will leads to weight loss.

4.3 Water absorption

The water absorption values of specimens taken at different intervals of time was tabulated in table.no.3 as below.

Table-3: Consolidate table showing percentage of water absorption

Cases	7 days	14 days	21 days	28 days	58 days	88 days	118 Days	148 days	178 days
Case-1	0.46	0.20	0.14	0.14	0.34	0.05	0.12	0.31	0.55
Case-2	0.70	0.25	0.25	0.16	0.34	0.05	0.13	0.34	0.62
Case-3	0.69	0.35	0.27	0.54	0.40	0.02	0.11	0.35	0.67
Case-4	0.25	0.27	0.13	1.14	0.30	0.04	0.14	0.34	0.64
Case-5	0.11	0.13	0.11	0.15	0.25	0.34	0.44	0.67	0.82
Case-6	0.17	0.13	0.27	1.83	0.24	0.45	0.55	0.74	0.90
Case-7	0.19	0.06	1.14	0.26	0.26	0.49	0.61	0.75	0.87

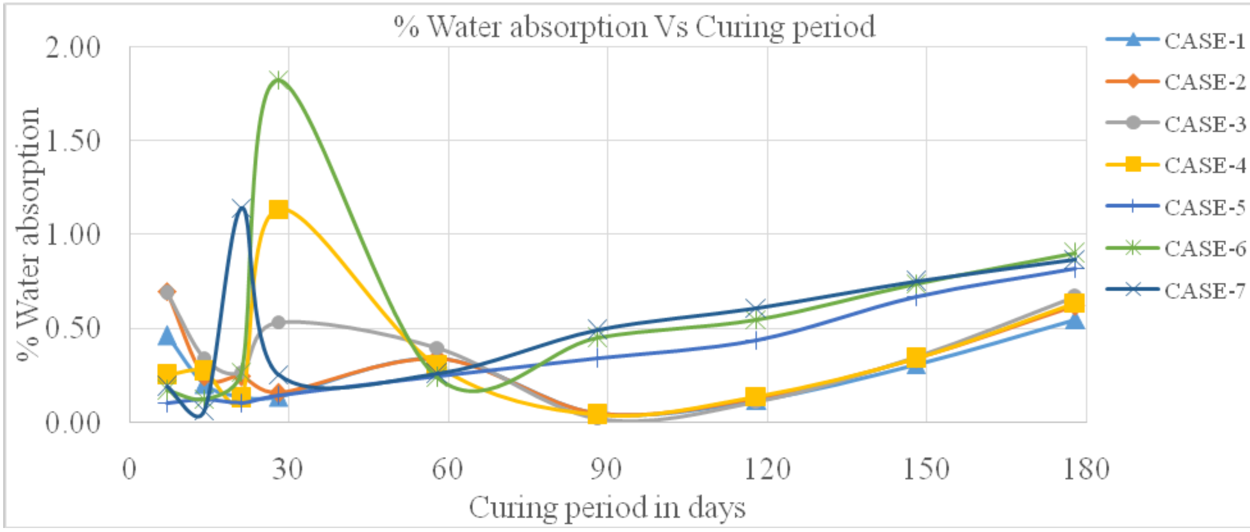
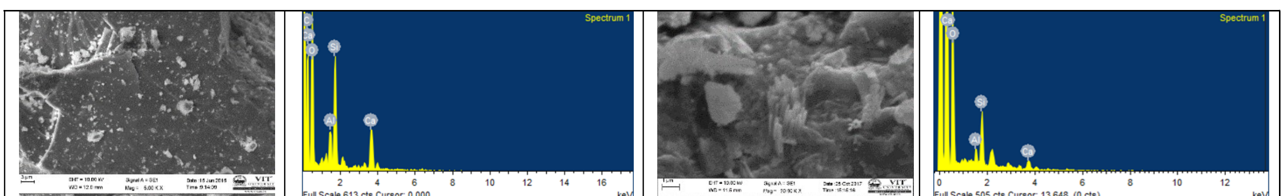


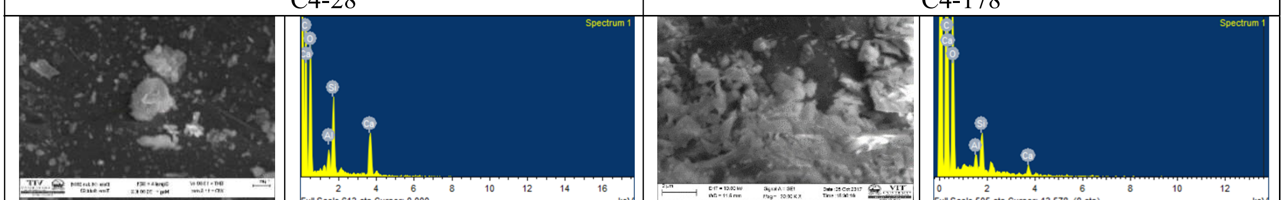
Fig-4: comparison between %water absorption vs curing period

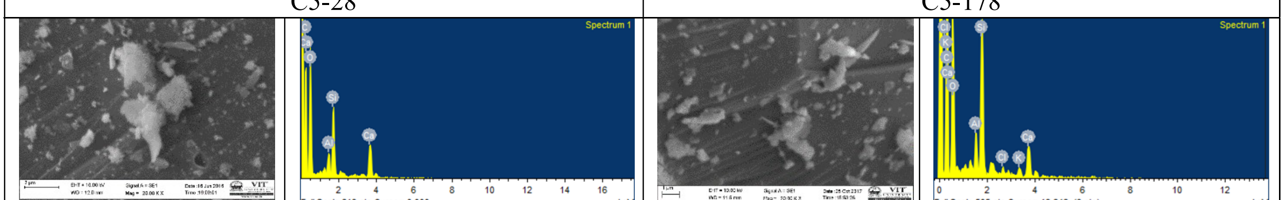
All specimens observed a greater water resistance to water absorption comparatively at 28 days and 178 days specimens made with commercially available admixture shows a greater value of water absorption. The specimens made without any reinforcement and without any admixture shows a less value of water absorption compared to all other cases.

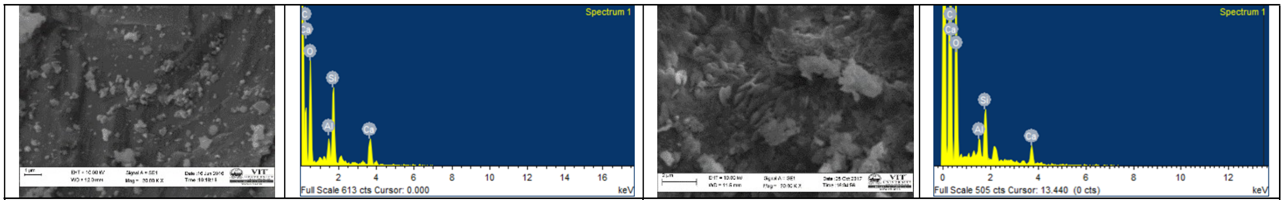
4.4 SEM and EDAX analysis:

The morphological evolution of the Portland slag cement at various intervals of time was done by SEM and EDAX analysis. The SEM and EDAX analysis shows a better pore refinement and grain refinement from 28 days to 178 days. The SEM image of specimens a made with commercial a commercial admixture show a less refinement where as other Images shows a better refinement.


C4-28 C4-178


C5-28 C5-178


C6-28 C6-178



C7-28	C7-178

Fig-5: comparison between SEM and EDAX images at 28 days and 178 days

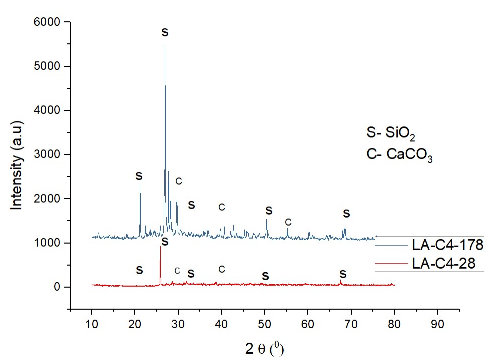
Table-4: Consolidate table showing EDAX Results

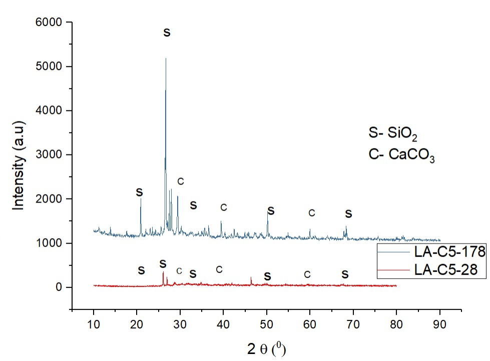
	C4-28	C4-178	C5-28	C5-178	C6-28	C6-178	C7-28	C7-178
Element	Wt%	Wt%	Wt%	Wt%	Wt%	Wt%	Wt%	Wt%
C-$CaCO_3$	21.1	-	27.8	65.9	24.8	45	1.36	62.2
O-SiO_2	48.4	75.55	44.2	29.8	46.7	35.4	55.1	30.8
Al-Al_2O_3	3.5	3.11	2.46	0.66	2.74	1.79	4.59	0.8
Si-SiO_2	12.4	14.1	9.43	1.97	10.5	9.74	19	3.09
Ca- Wallastonite	14.6	7.24	16.1	1.68	15.4	6.09	19.9	3.18

The EDAX analysis shows that an increment in $CaCO_3$ percentage in all the cases. The specimens made with calcium nitrate admixture shows comparatively a higher value of $CaCO_3$ percentage.

4.4 XRD-Analysis

The XRD analysis was done on concrete powder samples used with an angular range of 2θ =10 to 90 degrees at a radiation of λ=1.54 kvA^0, Voltage of 25kV and intensity of 25mA. Form the Phase identification analysis it is evident that silica and $CaCO_3$ are present in sample, after 28 days silica and $CaCO_3$ reacts with each other to form calcium silicate. The following XRD Patterns shows a high intensity of silica and calcium carbonate but diffraction spectra contain low intensity of alite, belite and tobermolite traces.





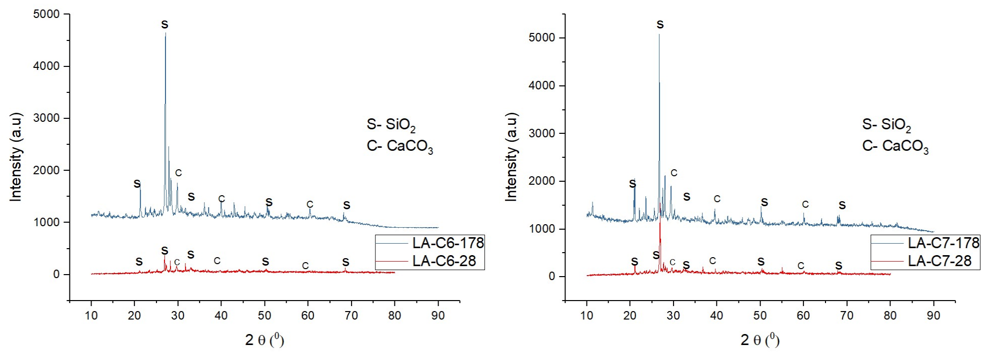


Fig. 6 X-rays pattern of Portland slag cement concrete

V. CONCLUSIONS

The controlled environment of hydrochloric acid showed influence on Portland slag cement concrete. The strength of all specimens decreased after exposing the specimens to 5% HCl solution. Comparatively the specimens made with commercially available admixtures were less affected by other cases. By the means of SEM, EDAX and XRD analysis the presence of hydration compounds and mineral compounds in time was highlighted.

REFERENCES

[1] JUMATE Elena, et al.,, Application of X Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) methods to the portland cement hydration processes, "Journal of Applied Sciences", Vol.No-2(25), Issue1/2012.

[2] Pengfei Huang et.al., Influence of HCl corrosion on the mechanical properties of concrete, "Cement and Concrete Research", Vol- 35,2005, PP: 584– 589.

[3] GiriPrasad.G, et al., Assessment of Self Compacting Concrete Immersed In Acidic Solutions, ACSGE-2009, Oct 25-27, BITS Pilani, India

[4] Maroliya M.K., A Qualitative Study of Reactive Powder Concrete using X-Ray Diffraction Technique, "IOSR Journal of Engineering", Volume 2, Issue 9 (September 2012), PP 12-16.

[5] Prof.N.K.Dhapekar, Study of phase composition of Ordinary Portland Cement Concrete using X-Ray Diffraction, "International Journal of Scientific & Engineering Research", Volume 6, Issue 11, November-2015.