Assessment of Carbonation on Strength Properties of Concrete Made of Mineral Admixtures

V. Suryaprakash Reddy, N. Venkat Rao, Ram Mohan Rao Papolu

Abstract: ***Concrete is one of the most suitable materials in the world which are used for construction. It becomes more versatile because of his suitability in almost all situations. Reinforced structures are subject to corrosion by various means. Carbonation is one of these means that causes corrosion of reinforced concrete structures. The service life of the structures has been reduced due to the deterioration of the structures because of the corrosion of the reinforced concrete due to carbonation. This paper focuses on the effect of carbonation on the mechanical properties of concrete composed of mineral admixtures, such as ground granulated blast furnace slag and silica fume, by partial replacement of the cement. In this experiment, silica fume replaced cement in 5%, 10%, 15% and ground granulated blast furnace slag replaced the cement in 10%, 20%, 30%. Samples such as cubes, cylinders and prisms were casted and cured. Certain number of these specimens were also placed in carbonation chamber and tested for compressive strength, tensile strength and flexural strength. Normal concrete samples are also tested and the results are compared.***

Keywords: *Carbonation, compressive strength, flexural strength, split tensile strength, Silica Fume.*

I. INTRODUCTION

Carbonation is widely recognized as the main cause of corrosion of reinforcement in concrete structures. Many structures in the world are deteriorating under the effect of carbonation. Carbonation is a physical and chemical process in which the carbon dioxide (CO2) present in the atmosphere reacts with the hydration products of the cement and change the physical and chemical properties of concrete. This mechanism is called carbonation of concrete.

The reaction of Ca (OH2) is considered as most responsible factors which reduces the ph value of the pore solution of the concrete. It reduces the ph value of the solution from (13<9).These reduction in ph value causes the initiation of de-passivation of the layer on the rebar embedded in the concrete. This phenomenon is called as Carbonation induced corrosion.

On one hand carbonation is responsible for the corrosion of reinforced concrete, on the other hand carbonation improves the mechanical properties of unreinforced concrete.

Revised Manuscript Received on October 05, 2019.

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The reduction in the porosity of concrete increases the compressive strength, split tensile strength and flexural strength. The rate of carbonation may be influenced by the type of pozzolanic material, water binder ratio, moisture content etc. Relative humidity will also play major role in the carbonation process for a favorable carbonation conditions the relative humidity should be 50-70%.

This paper deals with the Assessment of carbonation on strength properties of concrete made of mineral admixtures. The properties like compressive strength, split tensile strength, and flexural strength of carbonated concrete are determined and compared with the carbonated concrete made without mineral admixtures.

II. MATERIALS AND MIX PROPRTIONS

In This study materials used as cement, Fine Aggregates, Coarse Aggregates, Silica Fume, Ground Granulated Blast and Furnace Slag.

A. Cement

Ordinary Portland Cement (OPC) 53 grade was used which fulfill the requirements of IS 12269-19887. A few tests are conducted on the cement. The properties of cement were given in Table I.

Table I: cement test results

Physical Property	Values of OPC used	As per IS 12269-1987
Standard consistency	30.6%	---
Initial setting time	32minutes	Maximum of 30 minutes
Final setting time	10hours	Maximum of 600 minutes
Specific gravity	3.1	---

B. Aggregates

i. Fine Aggregate:

The Locally Available river sand passing through IS 4.75mm sieve is used which was coming under Zone II as per IS 383-1987. The properties of sand were given in Table II.

Table II: Properties of F.A.

Physical property	values
Specific gravity	2.589
Fineness modulus	2.62
Water Absorption	1.6%

ii. Coarse aggregate:

The Locally Available crushed aggregate of 10mm maximum size retained on IS 4.75mm sieve has been used as per IS 2386 - 1963 The properties of aggregates were given in Table III.

Table III: Properties of C.A.

Physical property	Values
Aggregate size	10
Specific gravity	2.62
Fineness modulus	2.71
Water Absorption	0.64%
Crushing value	0.49%
Impact value	12.6

C. Mineral Admixtures

i. Silica fume

It is a Non crystalline amorphous silicon dioxide polymorph of silica, which can be produced as a byproduct from silicon and Ferro silicon. It is a very finest powder consists of spherical particles with an average size of 150 nm particles. The physical properties of silica fume given in Table IV.

Table IV: Properties of Silica Fume.

Physical property	Values
Specific gravity	2.54

The chemical composition properties of silica fume given in Table V.

Table V: chemical composition of Silica Fume

Chemical composition	Values
Sio2 (Silicon dioxide)	93.0
MgO (Magnesium oxide)	0.6
Al2O3 (Aluminum oxide)	1.16
Fe2O3 (Ferric oxide)	0.3
K2O (Potassium oxide)	0.56
SO3 (sulfur trioxide)	0.11
Na2O (Sodium oxide)	0.89

ii. Ground granulated blast furnace slag

Ground granulated blast furnace slag is a byproduct of the steel industry which is a non-metallic product consisting of calcium, silicates and alumina silicates. When iron ore which consists of iron oxides silica and aluminum are added together with fluxing agents. Iron and molten slags are produced then through a specific process GGBS is produced.

The physical properties of Ground granulated blast furnace slag is given Table VI.

Table VI: Properties of Ground granulated blast furnace slag.

Physical property	Values
Specific gravity	2.8

The chemical composition properties of Ground granulated blast furnace slag given in Table VII.

Table VII: chemical composition of Ground granulated blast furnace slag

Chemical composition	Values (%)
Sio2 (Silicon dioxide)	20
MgO (Magnesium oxide)	6
Al2O3 (Aluminum oxide)	2
Fe2O3 (Ferric oxide)	2
K2O (Potassium oxide)	0.23
SO3 (sulfur trioxide)	12
Calcium oxide (Cao)	45

III. MIX DESIGN

In This experimental study design for M40 grade is from IS 10262-2009.water cement ratio is 0.41. The mix ratio has done as 1:1.83:2.65. Mix proportions as given in Table VIII.

Table VIII: Mix proportions

Constituents	CC	MIX 1	MIX 2	MIX 3
Cement	346	346	346	346
Water	181	181	181	181
Fine aggregate	632	632	632	632
Coarse aggregate	912	912	912	912
Silica fume	-	5%	10%	15%
Ground granulated blast furnace slag	-	10%	20%	30%

IV. METHODOLOGY

A. Experimental Program

Specimens of four mixes are casted. One mix is a normal conventional concrete (cc) of M40grade and other three mixes are adding of mineral admixtures to the concrete with the mix proportions of a given Table VIII. Firstly place the coarse aggregates, fine aggregates cement in wet dry place ,mix it for a time interval of five minutes, Then place the admixtures and mix it slowly ,after completion of a mixing of materials. Then water is added slowly to the dry mixture, then Concrete is filled into the cubes of dimensions 150x150mm, Cylinders of the diameter150*300mm, Beams of the diameter 150*150*720mm To get full compaction of moulds .compact the moulds with the compaction rod to fill of gaps in a concrete. After the compaction, Place the moulds for the de moulded for 24 hrs. Then place the specimens in the curing tank for 7 and 28 days, and specimens are to be kept in carbonation chamber in a pre-determined time of 2 months. Then the specimens are to be taken out for tests of Compressive strength, flexural strength, and split tensile strength. The specimens in carbonation chamber as shown in Fig.1.

Fig.1: specimens in carbonation chamber

V. RESULTS AND DISCUSSIONS

A. Compressive strength

The Compressive strength results were given in Table IX, and the fig.2 shows the strengths at 7day, 28 day. Fig.3 shows the crack pattern of the cube.

Table IX: Compressive Strength Results.

Trial	7 Day (Mpa)	28 Day (Mpa)
Conventional concrete	41	45
Mix 1 (5% Silica fume + 10% Ggbs)	42.6	45.8
Mix 2(10% Silica fume + 20% Ggbs)	43.8	46.5
Mix3(15% Silica fume + 30% Ggbs)	45.9	48.4

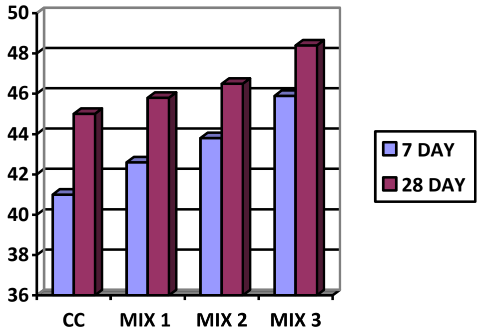

Fig.2: compressive strength of concrete.

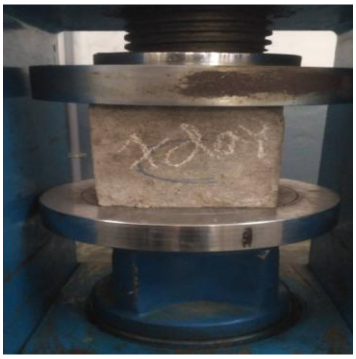

Fig.3: compressive strength of concrete.

B. Split Tensile strength

The Split tensile strength results were given in Table X. these values are shown in fig.4, and fig.5 shows the cylinder placed for test.

Table X: Split Tensile Strength Results.

Trial	7 Day (Mpa)	28 Day (Mpa)
Conventional concrete	3.19	3.26
Mix 1 (5% Silica fume + 10% Ggbs)	3.34	3.47
Mix 2(10% Silica fume + 20% Ggbs)	3.50	3.68
Mix3(15% Silica fume + 30% Ggbs)	3.69	3.97

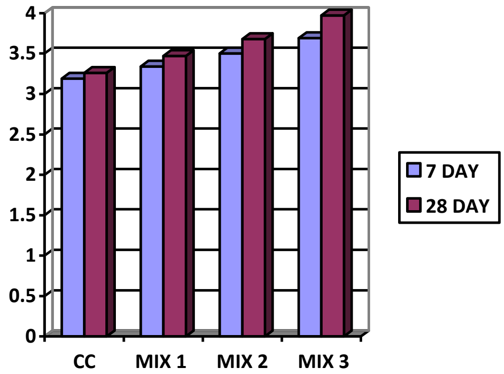

Fig.4: Split tensile strength of concrete.

Fig.5: Split tensile strength of concrete.

C. Flexural strength

The Flexural strength results were given in Table XI. The fig.6 shows the strength values obtained at 7days and 28days of curing. Fig.7 shows the beam placed for testing.

Table XI: Flexural strength Results

Trial	7 Day (Mpa)	28 Day (Mpa)
Conventional concrete	4.59	4.62
Mix 1 (5% Silica fume + 10% Ggbs)	4.72	4.83
Mix 2(10% Silica fume + 20% Ggbs)	4.98	5.26
Mix3 (15% Silica fume + 30% Ggbs)	5.12	5.69

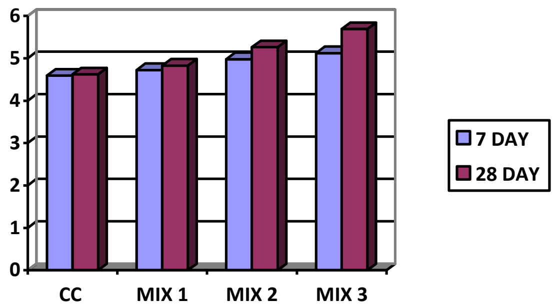

Fig.6: Flexural strength of concrete.

Retrieval Number: L28581081219/2019©BEIESP
*DOI: 10.35940/ijitee.*L2858.*1081219*

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Fig.7: Flexural strength of concrete.

VI. CONCLUSION

1. The compressive strength obtained for conventional concrete at 28 days of curing is 45mpa and the compressive strength values obtained for mix1 is 45.8mpa, mix2 is 46.8mpa, and mix3 is 48.4mpa.
2. Results depict that 1.78%, increase in its strength for mix1, 3.3%, increase in its strength for mix2, and 7.56 %, increase in its strength for mix3. When compared to conventional concrete.
3. The split tensile strength obtained for conventional concrete at 28 days of curing is 3.26mpa, and the split tensile strength values obtained for mix1 is 3.47mpa, mix2 is 3.68mpa, mix3 is 3.97mpa
4. Results depict that 6.44%, increase in its strength for mix1 12.88 %, increase in its strength for mix2, and 21.72%, increase in its strength for mix3. When compared to conventional concrete.
5. The flexural strength obtained for conventional concrete at 28 days of curing is4.62mpa, and the flexural strength values obtained for mix1 is 4.83mpa is, mix2 is 5.26mpa, mix3 is 5.69mpa.
6. Results depict that 4.5%, increase in its strength for mix1, 13.8%, increase in its strength for mix2, and 23.16%, increase in its strength for mix3. When compared to conventional concrete.

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