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Effect of Various Curing on Mechanical Properties of High Performance Concrete Containing Supplementary Cementitious Material

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Abstract—*In recent years, there is a growing interest in the high performance concrete which provides high strength. The aim of this research paper was to evaluate the efficient curing condition for high performance concrete (HPC) which containing different supplementary cementitious material, to achieve target strength more than 60MPa. Mix design for M60 was achieved using ACI code, by trial and error method. Three different concrete mix with different replacement of cement with 10% silica fume (SF), 20% ground granulated blast furnace slag (GGBS), 25% fly ash (FA) were used. Three different curing methods namely water curing, plastic wrapping and membrane (coal tar epoxy) curing, to cure the specimens until the day of curing. The mechanical properties (compressive strength and split tensile strength) were examined. Maximum strength was obtained by 20% GGBS replacement with water curing method. After 28 days compressive strength for the plastic wrapping and membrane curing is decreased by respectively 6% to 8% and 25% to 30% compared to water curing for GGBS, SF and FA. Split tensile strength results are almost same for the water curing and plastic wrapping. The drying rate was significant when the specimens were subjected to membrane (coal tar epoxy) method of curing.*

1. INTRODUCTION

In recent years there is a growing interest in the use of high-performance concretes which provide high strength. It has generally been accepted that curing is more important for concrete with mineral admixtures. The supplementary cementitious materials were used in the concrete only because of their availability and just for economical considerations. For high performance concrete necessary supplementary cementitious materials such as silica fume(SF), ground granulated blast furnace slag(GGBS), fly ash(FA) is use. This materials present some properties, which cannot be met by using OPS only (Neville 1995).

Canan[3] observed the Mineral admixtures (silica fume) having high values of fineness and pozzolanic activity increase the compressive strength. Microfiller materials fill both the interfaces and the bulk paste, hence the sorptivity coefficient of concrete decreases. According to Khan[11] the silica fume content increased the early strength for all mixes. Concrete mixes containing 30% pulverised fuel ash and above with or without SF were not able to achieve the strength. The incorporation of 8 to 12% SF yielded the strength and permeability values.

2. RESEARCH AIM

To develop a durable concrete mix with good workability and high strength to with stand worst environmental conditions. To study the mechanical properties of these concrete mixes in terms of changes in strength and elasticity properties with time: To assess the effect of concrete containing a different mineral admixtures cured under different curing condition. To finding out the most appropriate method of curing may be apply on site construction or on precast concrete.

3. MATERIAL USED

3.1 Cement

The cement used in this experimental work is 53 grades Ordinary Portland Cement which conforming IS 12269:1987. The specific gravity of the cement is 3.15. The initial and final setting times were found as 103 minutes and 248 minutes respectively. Standard consistency of cement was 29.50%. The chemical property of cement as per Table 1.

Table 1: Chemical property of OPC

Compound	Content, %weight
SiO2 (Silicon dioxide)	24.41
Al2O3 (Aluminum oxide)	5.65
Fe2O3 (iron oxide)	3.62
CaO (Calcium oxide)	59.15
MgO (magnesium oxide)	1.18

P2O5 (phosphorus pentoxide)	0.31
K2O (potassium oxide)	0.54
Na2O (sodium oxide)	0.47
SO3 (sulfur trioxide)	2.64
SrO2 (strontium peroxide)	0.017
Mn2O3 (manganese oxide)	0.43
L.O.I	1.31

3.2 Fine Aggregate

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.75 and fineness modulus of 3.338 are used as fine aggregate. The loose and compacted bulk density values of sand are 1094and 1162 kg/m3 respectively, the water absorption of 1.538%.

3.3 Coarse Aggregate

Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 16mm having the specific gravity value of 2.885and fineness modulus of 7.386 are used as coarse aggregate. The water absorption of 0.504%.

3.4 Water

Tap water confirming IS 456:2000 was used for this experiment work. This is free from oil, alkalis, sugar, organic material and salts.

3.5 Super Plasticizer

We had used sikament FF super plasticizer. By substantial improvements in workability without increased water or the risk of segregation. Relative density of this chemical is 1.250. pH value is 8-12.

3.6 Fly ash

Fly ash (FA) class F, known also as pulverized- fuel ash, is the by product obtained by electrostatic and mechanical means from flue gases of power station furnaces fired with pulverized coal. Chemical properties of fly ash as per Table 2.

3.7 Silica fume

Silica fume (SF) is a extremely reactive pozzolanic material. It is a by-product obtained from the manufacture of silicon or ferrosilicon. It is extracted from the flue gases from electric arc furnaces. SF particles are very fine with particle sizes about hundred times smaller than those of average size of OPC particles. It is a densified powder or is in the form of water slurry. Chemical properties of silica fume as per Table 2.

3.8 Ground granulated blast furnace slag

Ground granulated blast furnace slag (GGBS) is a by product achieved in the manufacturing of pig iron, when iron ore is reduced to pig iron. Chemical properties of GGBS as per Table 2.

Table 2: Chemical property of mineral admixture

Compound	Content, %weight		
	Fly ash	Silica fume	GGBS
SiO2	59	97	35
Al2O3	21	0.2	11
Fe2O3	3.70	0.5	1
CaO	6.90	0.2	42
MgO	1.40	0.5	8
K2O	0.90	0.5	0.4
SO3	1	0.15	0.6
L.O.I	4.62	0.95	2

4. MIX DESIGN

In this study high strength concrete was designed based on ACI 211-4R-93(Guide for selecting Proportions for High-strength concrete with Portland cement and fly-ash) guidelines. Mix design for M60 was achieved using trial and error method. Three different concrete mix with different replacement of cement with 10% silica fume(SF), 20% ground granulated blast furnace slag(GGBS), 25% fly ash(FA) were used..Final mix design is 1:0.96:1.7:0.31. For all mix w/c ratio was same.

Mix M1 10% replacement of silica fume with cement

Mix M2 20% replacement of GGBS with cement

Mix M3 25% replacement of fly ash. With cement

Table 3: Mix Proportion for M-60 Grade concrete

Mix no	W/c ratio	Water kg/m3	Cement kg/m3	FA kg/m3	CA kg/m3	plasicizer %	Min. Adx.
M1	0.31	177	515	535	1100	1.5%	57
M2	0.31	177	457	542	1100	1.2%	114
M3	0.31	177	429	524	1100	1.0%	163

5. CURING METHODS

A. Water curing(CM1)

In this method of curing, specimen fully immersed in water at the test age.

B. Plastic wrapping(CM2)

Plastic sheet materials, such as polyethylene film, can be used to cure concrete. Polyethylene film is a lightweight, effective moisture retarder and is easily applied to complex as well as simple shapes. Polyethylene film should conform to ASTM C 171 ,which specifies a 0.10-mm thickness for curing concrete, but lists only clear and white film.

C. Membrane curing(CM3)

Liquid membrane-forming compounds consisting of waxes, resins, chlorinated rubber, and other materials can be used to retard or reduce evaporation of moisture from concrete.Curing compounds should be able to maintain the relative humidity of the concrete surface above 80% for seven days to sustain cement hydration. In this paper coal tar epoxy was used as membrane curing material.Only one smooth, even coat is applied at a typical rate of 3 to 4 m^2 per liter, but products may vary, so manufacturer's recommended application rates should be followed.

6. RESULT DISCUSSION

A. Test on fresh concretekability of fresh concrete was determined by slump flow test. Slump test resultsas Table 4.

Table 4: Slump test results

Mix	Slump(mm)
M1	43
M2	57
M3	61

B. Test on hardened concrete

1. Compressive strength test results

According to IS: 516 : 1959 testing specimen size 150mm×150mm×150mm used to find the compressive strength. Test was conducted afer 7 days ans 28 days.

The compressive strength after 7 days is nearly to equal for water curing and plastic wrapping. 7 days strength for membrane curing(coal tar epoxy)decreased by 20 to 25 % compared to water and plastic wrapping.Cement replacement of 20% with GGBS leads to increase in compressive strength after 7 days and 28 days for water curing for M60 grade concrete. After 28 days compressive strength for the plastic wrapping is decreased by 4% to 8% compared to water curing for GGBS, SF and FA.Strength for membrane curing is decreased by 20% to 30% compared water curing.

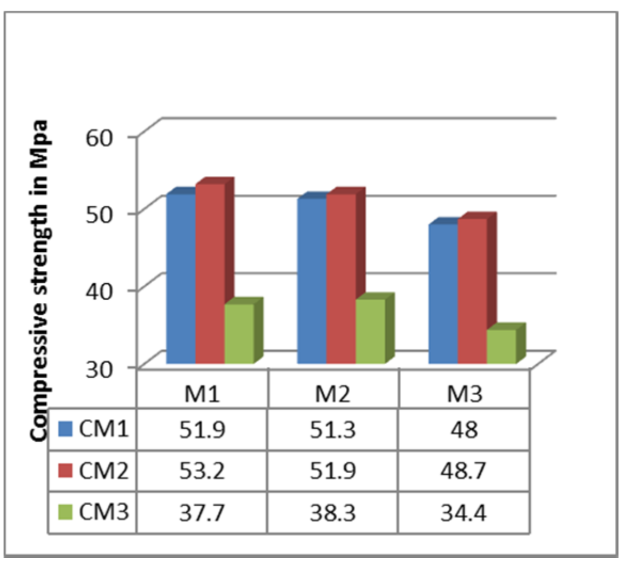

Fig. 1 Compressive Strength comparison at 7day

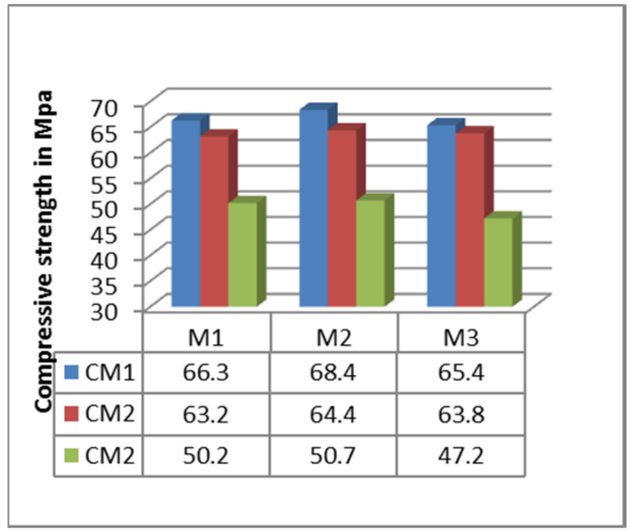

Fig. 2 Compressive Strength comparison at 28day

2. Split tensile strength test result

Split tensile strength test was conducted on cylinder, 150mm diameter and 300 mm height. According to IS 5816:1999. Test was conducted afer 7 days ans 28 days

Chart indicates that after 7 days split tensile strength was maximum in water curing for 10% replacement of silica fume. For all three replacement of SF,FA,GGBS with cement gives the lowest split strength for membrane curing.The maximum split tensile strength was achieved by 10% replacement of silica fume with cement for the water curing and plastic wrapping. For GGBS and FA, 20% and 25% replacement, tensile strength is lower compare to SF which is about 5% and 15% respectively.Split tensile strength results are almost same for the water curing and plastic wrapping.

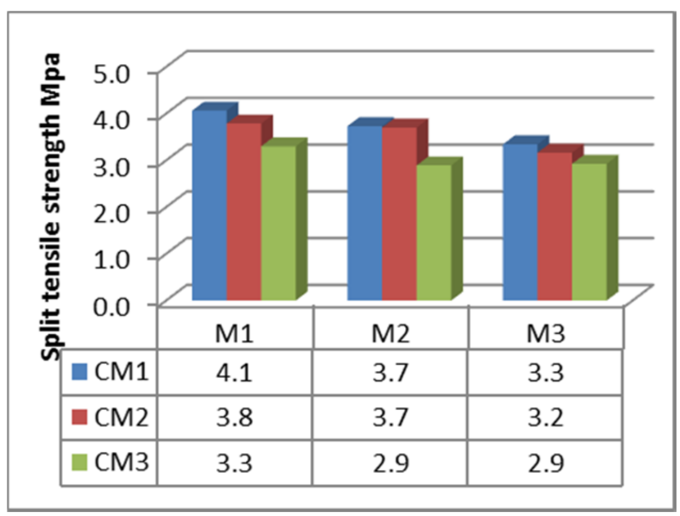

Fig. 3 Split tensile Strength comparison at 7day

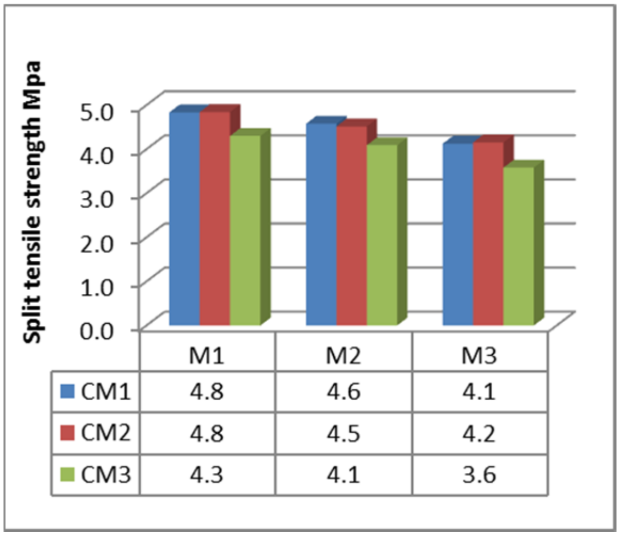

Fig. 4 Split tensile Strength comparison at 28days

7. CONCLUSIONS

1. Mix design for M60 is achieved using ACI code, by trial and error method, and after all trials, mix design proportion is 1:0.96:1.92:0.31
2. After obtaining mix design, % replacement of cement with GGBS, SF, and FA obtained as 20%, 10% and 25% respectively.
3. In SF and FA, 10% and 25% replacement, compressive strength is lower compare to GGBS which is about 4% and 7% respectively.
4. After 28 days compressive strength for the plastic wrapping is decreased by 4% to 8% compared to water curing for GGBS, SF and FA.
5. For membrane curing(coal tar epoxy) the strength after 28 days is decreased by 25% to 30% compared to water curing for the replacement of FA, GGBS, SF with cement
6. The rate of drying was significant when the specimens were subjected to membrane method of curing. This thus hampered the hydration process and thus affects the mechanical properties of the hardened concrete.

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