AN EXPERIMENTAL STUDY ON STRENGTH BEHAVIOR OF SELF CURED HIGH PERFORMANCE CONCRETE

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Abstract

Now a days requirement of water for concreting is very high.1m^3 of concrete requires 3m^3 of water for construction, most of which is needed for curing purpose only. For such applications the fresh concrete must possess less water consumption and good strength. The concept of Self Curing HPC is to reduce the water evaporation and to give good performance in construction. The main objective of this work is to determine the ultimate strength, load-deflection characteristics, flexural and shear behavior of beam by adding the silica fume and metakaolin as mineral admixture for cement and superplasticiser(SP) and polyethylene glycol(PEG) as chemical admixture. By varying silica fume as the percentage from 0.5% to 1.5% weight of cement at 0.5% intervals and metakaolin as the percentage from 5% to 15% at 5% intervals was studied. The mix designs with strengths of 50 N/mm^2 were considered. This study was carried out using several tests, which included workability and mechanical properties of SCHPC. Workability was determined through slump flow. Mechanical characteristics were obtained through compressive strength, splitting tensile strength and flexural strength test. From the test results, found out that SCHPC with 1.5% Silica Fume and 5% Metakaolin gives better results when compared with other mixes.

Key Words: *metakaolin, superplasticiser, silica fume, workability , polyethylene glycol, Compressive Strength.*

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1. INTRODUCTION

Concrete is probably the most extensively used construction material in the world. The addition of mineral admixture in cement has dramatically increased along with the development of concrete industry, due to the consideration of cost saving, energy saving, environmental protection and conservation of resources. Maintenance and repair of concrete structures is a growing problem involving significant expenditure. It has been made possible to process the material to satisfy more stringent performance requirements, especially long – term durability. High performance is generally assumed to be synonymous with high strength, although this is not true in every case. It is generally accepted, that the high performance of the very concrete contributes to low permeability, stronger and denser transition zone between aggregate and cement paste in the concrete. This also adds to the abrasion resistance of concrete. According to ACI " High Performance Concrete is defined as concrete which meets special performance and uniformity requirements that cannot always be achieved routinely by using conventional materials and normal mixing, placing and curing practices.

1.2 HIGH PERFORMANCE CONCRETE

High-performance concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concretes that must meet a combination of performance requirements. Special mixing, placing, and curing practices may be needed to produce and handle high-performance concrete. Extensive performance tests are usually required to demonstrate compliance with specific project needs (ASCE 1993, Russell 1999, and Bickley and Mitchell 2001). High-performance concrete has been primarily used in tunnels, bridges, and tall buildings for its strength, durability, and high modulus of elasticity (Fig. 17-1). It has also been used in shotcrete repair, poles, parking garages, and agricultural applications.

High-performance concrete characteristics are developed for particular applications and environments.

Some of the properties that may be required include:

a) High strength
b) High early strength
c) High modulus of elasticity
d) High abrasion resistance
e) High durability and long life in severe environments
f) Low permeability and diffusion
g) Resistance to chemical attack
h) High resistance to frost and deicer scaling damage
i) Toughness and impact resistance
j) Volume stability
k) Ease of placement
l) Compaction without segregation
m) Inhibition of bacterial and mold growth

1.3 SELF CURING CONCRETE

Internal curing provides a set of water-filled reservoirs within the concrete that supply water on demand to the hydrating cement paste from the time of mixing (i.e., for reducing plastic shrinkage and maintaining workability) until the time when moisture equilibrium is achieved between the reservoirs and the surrounding cement paste for reducing dry shrinkage. Internal curing is achieved by replacing a percentage of coarse aggregate with light weight aggregate such as expanded shale. The light weight aggregate i.e., the shale is been heated at a temperature of 2000°F after which it is soaked in water for 24 hours and mixed with cement and fine aggregate. This mixture is been poured into the mould and external vibration was used to consolidate the specimen after casting immediately. The water stored in the lightweight aggregates is typically stored in pores that are larger than those in a hydrating cement paste. As a result the water moves from the light weight aggregate to the surrounding cement paste keeping the small pores saturated. The internal curing process utilizes cement more efficiently during the hydration process. Internal curing improves the workability and reduces the cracks due to plastic, drying and thermal shrinkage. The strength of the concrete is increased as the bond

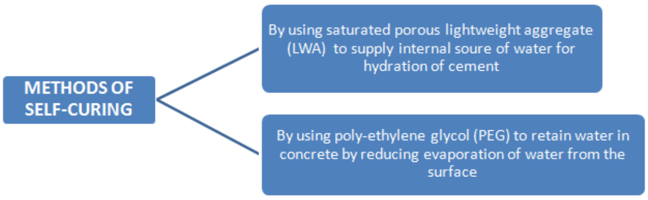

Fig.1 Methods of Self Curing

1.4 NEED FOR THIS STUDY

High Performance concrete works out to be economical, even though it's initial cost is higher than that of conventional concrete because the use of High Performance concrete in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs. Also construction industry use lot of water in the name of curing. Not only to save water for the sustainable development of the environment but also to promote indoor and outdoor construction activities even in remote areas where there is scarcity of water.

2. OBJECTIVES

The objective of the present investigation is to develop and achieve the Self Cured High Performance Concrete and to study its characteristics in fresh and hardened state.

In this project it is proposed to study

1. Mix proportions for High Performance Concrete and to obtain the optimum percentage of Silica Fume and Metakaolin to be adding in Concrete.
2. Study the workability characteristics of SCHPC with addition of Silica Fume and Metakaolin using Slump-cone test, V-funnel test and L-Box Test.
3. The chemical admixture used for workability is Polyethylene Glycol(PEG 400) at suitable dosages.
4. To study hardened SCHPC properties using, Compressive strength, Split Tensile strength and Flexural strength Testing.

3. EXPERIMENTAL STUDY

3.1 Materials and properties

A. *cement*

Cement is the well-known building material with adhesive and cohesive properties, which is capable of binding mineral fragment into compact mass. There are several types of cement. The most popular Ordinary Portland cement (OPC-53) is used in this study.

B. *Fine aggregate*

Aggregate which is passed through 4.75 mm IS sieve and retained on 75 micron IS sieve is termed as fine aggregate. It fills the voids in coarse aggregate. Usually, the natural river sand is used as fine aggregate. Ordinary river sand conforming IS 383-1970 is used in this project.

C. *Coarse aggregate*

Aggregate which passes through 75 mm IS sieve and retained on 4.75 mm IS sieve are known as coarse aggregate. Aggregates should be properly screened and if necessary washed before use. Coarse aggregates containing flat, elongated or flaky pieces should be rejected. The grading of coarse aggregates should be as per specifications of IS 383-1970. In this project, 10 mm size of coarse aggregate is used.

Table 1 Material Properties

Properties \ Materials		cement	Fine aggregate	Coarse aggregate
Fineness modulus		2%	2.84	3.53
Consistency		31%	-	-
Specific gravity		3.15	2.62	2.80
Moisture content		-	NIL	NIL
Water absorption		-	0.5%	0.4%
Bulk density	**Loose state**	-	1441 kg/m3	1471 kg/m3
	Compacted state	-	1498 kg/m3	1505 kg/m3

D.*Water*

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts etc. The water inside the college campus is used for this study.

E. *Metakaolin*

Metakaolin is a dehydoxylated form of the clay mineral kaolinite. The particle size of Metakaolin is smaller than cement particles, but not as fine as silica fume. Research on metakaolin shows that is an excellent pozzolanic material which can improve strength, durability and other mechanical properties of concrete. Metakaolin reduces the workability of concrete but suitable use of superplasticizers can compensate this reduction

F. ***Silica fume***

Silica fume not only provides an extremely rapid pozzolanic reaction, but its very fine size also provides a beneficial contribution to concrete. Silica fume tends to improve both mechanical properties and durability. Silica fume concretes continue to gain strength under a variety of curing conditions, including unfavorable ones. Thus the concretes with silica fume appear to be more robust to early drying than similar concretes that do not contain silica fume. Silica fume is normally used in combination with high-range water reducers and increases achievable strength levels dramatically.

G. ***Superplasticizer***

The Superplasticizer is an essential component of self compacting concrete. To provide the necessary workability. Conplast SP430 is a chloride free, superplasticising admixture based on selected sulphonated naphthalene polymers. It is used in prestressed concrete and with sulphate resisting cements and marine aggregates. It is supplied as a brown solution which instantly disperses in water. Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of concrete to perform more effectively.

H. ***Polyethylene glycol(curing compound)***

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H(OCH2 CH2)n OH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. It appears to be water soluble. It is nontoxic and odourless. The specific gravity is 1.13. The polyethylene-glycol is used to reduce water evaporation from concrete, and hence increase the water retention capacity of concrete which leads to improved compressive strength. The use of polyethylene-glycol in concrete mixes improves the mechanical properties of concretes which may be attributed to a better water retention and causes continuation of the hydration process of cement past resulting in less voids and pores, and greater bond force between the cement paste and aggregates.

Fig.2 Polyethylene Glycol 400(PEG 400)

I. ***Mix Proportioning***

The mix design is done according to the IS 10262(2009) design method.

M50 Grade concrete having mix proportion 1 : 1.46 : 3.11was used with 0.375 w/c ratios.

4. CASTING OF CUBES

The dimensions of all the specimens were identical. The length of cubes was 150mm and the cross sectional dimensions were 150 mm x 150 mm. The design mix ratio was adopted for designing the cube.

The compressive strength on hardened concrete were performed on Universal testing machine. Concrete cubes of size 150x150x150mm were cast. Total 48 cubes were casted(3 cubes for each combination of SF & MK) for determination of compressive strength. Compressive strength of concrete cubes was tested at 7 days and 28 days. The number of specimens casted as per the below-mentioned details.

Table 2 Description of Mix ID

SILICA FUME(%)	METAKOLIN(%)					
	7 days			28 days		
0.5	5	10	15	5	10	15
1	5	10	15	5	10	15
1.5	5	10	15	5	10	15

5.TESTING OF CUBES

1. ***Experimental Setup***

The compressive strength test for cubes was conducted in compression testing machine at the rate of 140 kg/cm^2/min as per IS 516: 1964 and the ultimate loads were recorded.

Fig 3. Experimental Setup

The bearing surface of machine was wiped off clean and the surface of the specimen was cleaned. The specimen was placed in machine and the axis of the specimen was carefully aligned at the centre of loading frame. The load was applied at a constant rate of 140 kg/cm^2/min until the specimen fails and the maximum load applied on specimen was recorded.

5. RESULTS & DISCUSSION

A. *Workability:*

Various mixes of freshly mixed concrete were tested for workability by slump value. It was observed that, the workability decreases with increase in Silica fume content in the mix. The mix with cement as the only binder, the workability was medium. As per the table below it shows that there is in increase in workability with the addition of Superplasticiser in concrete.

B. *Compressive strength:*

Various mixes of concrete were tested for compressive strength. Maximum compressive strength value at 7 days is obtained 36.75 Mpa. Maximum compressive strength value at 28 days is obtained is 56 Mpa.

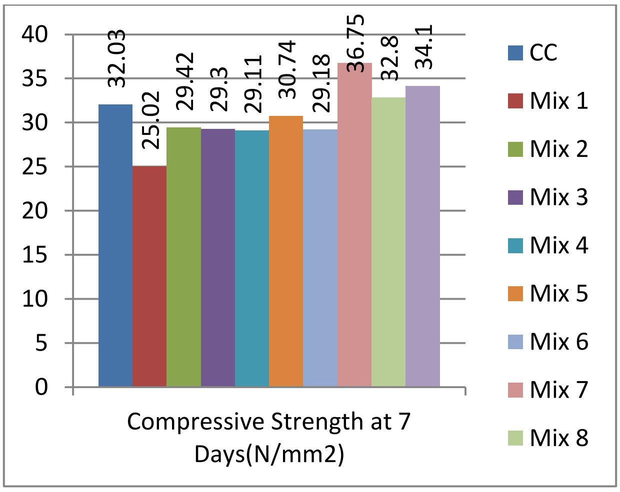

Fig 4. Compressive Strength Of Concrete At 7th Day

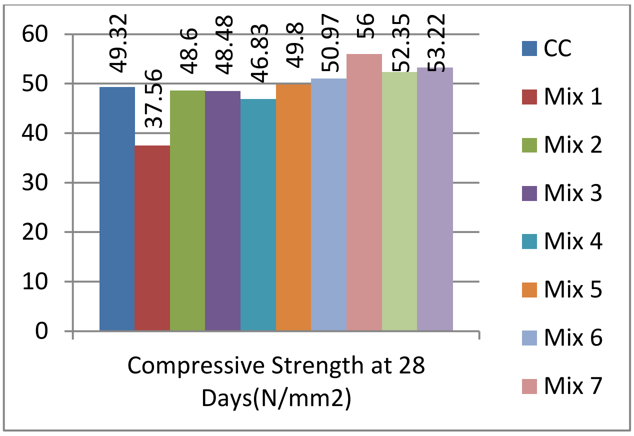

Fig 5. Compressive Strength Of Concrete At 28th Day

The chart shows the 7 and 28 days compressive strength of cube. The values are plotted to this chart. From this chart, the optimum value is determined. The optimum mix is founded to be **MIX 7 (SF 1.5% and MK 5%).**

6.CONCLUSION

By adding and varying Silica Fume and Metakaolin with percentages in concrete is studied and the following conclusions are made from this experimental study.

1. The results obtained from the study it is clear that the mechanical properties such as strength and workability are improved by adding 1.5% SF and 5% MK, and 2% SP.
2. The result also showed that by adding Polyethylene Glycol as 0.2% for self curing also increases strength than CC.
3. By 7th and 28th days compressive strength result the values 36.75 N/mm^2 and 56 N/mm^2 are found to be Optimum.

REFERENCES

1. R. Aarthi, R. Venkatakrishnaiah, Strength Behavior of Self-Curing Fly Ash Concrete using Steel Fiber, Volume: 2 Issue: 1 08-May-2014,ISSN_NO: 2320-723X
2. Akanksha A. Patil, Prof. M. R. Vyawahare, Comparative study on compressive strength of Self cured SCC and Normally cured SCC, ISSN : 2248-9622, Vol. 4, Issue 11(Version - 5), November 2014, pp.139-142
3. Ankith MK, Self Curing Concrete with Light Weight Aggregate, ISSN (Online): 2347-3878, Impact Factor (2014): 3.05
4. K.Bala Subramanian, A. Siva, S. Swaminathan, Arul. M. G. Ajin, Development of High Strength Self Curing Concrete Using Super Absorbing Polymer, Vol:9, No:12, 2015
5. M.Manoj Kumar and D.Maruthachalam, Experimental Investigation on Self-curing Concrete, Issue 3 volume 2, March-April 2013 ISSN 2249-9954

6. Mohanraj.A, Rajendran.M, Ramesh.A.S, Mahalakshmi.M, Manoj Prabhakar.S, An Experimental Investigation of Eco-Friendly Self-Curing Concrete Incorporated with Polyethylene Glycol, Vol. 1, Issue 2, October 2014
7. P.Muthupriya, Dr.K.Subramanian, Dr.B.G.Vishnuram, Investigation On Behaviour Of High Performance Reinforced Concrete Columns With Metakaolin And Fly Ash As Admixture, IJAET/Vol.II/ Issue I/January-March 2011/190-202
8. B. B. Patil, P. D. Kumbhar, Strength and Durability Properties of High Performance Concrete incorporating High Reactivity Metakaolin, Vol.2, Issue.3, May-June 2012 pp-1099-1104
9. Shibin C. Haroon, V. Sreevidya, R. Venkatasubramani, Strength studies on self curing High Performance Fibre Reinforced Concrete (HPFRC), ISSN 2319-5347, Vol. 04, No. 03, July 2015
10. K.Vedhasakthi, M. Saravanan, Development Of Normal Strength And High Strength Self Curing Concrete Using Super Absorbing Polymers (SAP) And Comparison Of Strength Characteristics, Volume: 03 Issue: 10 | Oct-2014 2319-1163 | pISSN: 2321-7308