Mechanical Properties Investigation of High Volume Fly Ash Concrete Cured With Synthetic and Bio Polymer as Self Curing Agent

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Abstract **The curing process is one of the most important part of concrete construction work .Concrete properties like strength, durability, permeability and surface hardness is predominantly depends on the curing process .It is also vital for early age cracking like autogenous shrinkage which alter the durability of concrete .Many times true curing is arduous because of manpower inaccessibility, lack of water and unapproachable parts of structure. Self- curing is the concept which is used nowadays. Self-curing agents retains the water, which leads to reduce water evaporation from the concrete. In this investigation high volume fly ash concrete is used to maximize the use of fly ash as still in India small portion of fly ash is used as compare to its production. This study investigates comparison of the mechanical properties of high volume fly ash concrete when it is self cured by synthetic polymer polyethylene glycol and biopolymer Spinacia oleracea .The criterion includes the percentage of fly ash and dosage of polyethylene glycol and Spinacia oleracea and age in curing .Workability, compressive strength and durability were determined as performance specifications for this investigation. It was found that Spinacia oleracea shows the best results compare to polyethylene glycol.**

Keywords — Synthetic, self curing agent, Polymer, Polyethylene glycol, Spinacia oleracea and autogenous shrinkage.

I. INTRODUCTION

Water is one of the most important elements of the earth for the human being and with time potable water quantity is decreasing day by day. Over this construction industry demand, a large amount of water for curing purposes to minimize this demand, a concept of self-curing is introduced. Self-curing, not only save water, but also promote construction activities in remote areas where there is the shortage of water. Whenever construction works are done at the heights, sloped part of structure and pavements, providing regular curing is difficult. In case of high performance concrete or high strength concrete, which are formed at low water-cement ratio and by addition of fly ash .In such concrete at the time of the hydration and pozzolanic reactions the capillary pores within the microstructure get depercolate which leads in lowering the imbibitions rate of external water, resulting in self-desiccation at depths just a few centimeters below the external water surface. This self-desiccation creates internal stresses that may contribute to early-age cracking of the concrete. [3], [12]

The requirement of internal curing initiates directly from the fundamental nature of cement hydration process .The mixture of cement and water reacts to form crystalline and gel hydration products in which water combines into these hydration products generally inhabited less space than water in its bulk form [2].Because of this in low water-cement ratio internal curing becomes beneficial as permeability of concrete, rapidly vanishes, which discontinue the percolation of external water from the surface to the interior concrete [9].

This condition rectified by using pre-wetted lightweight aggregate (LWA) in concrete mixture and the superabsorbent polymer which get evenly distributed in the concrete mix and provide water evenly and gradually with time. But as they release water from them, they create voids within in case of LWA and at their places in case of super absorbent polymer which affect the compressive strength and durability of concrete [13].

The demerit of superabsorbent polymers and lightweight aggregate limited their use, which culminates another concept of use of polyethylene glycol chemical which are hydrophilic means which gets dissolved in water and reduces their water evaporation without compromising with concrete properties [8]. The compressive strength of concrete show increment when treated with PEG as compared to normally cured concrete moreover with an increase in the molecules of PEG the increment in strength

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was more [14]. Biomaterials like Erukkampal, Calotropis gigantea, Spinacia oleracea is also used as a self-curing agents. These plants are widely available in India and many parts of Asia. These plants were used because of polymeric chemical nature.[10]

II. EXPERIMENTAL APPROACH

The importance of curing and merits of self-curing is discussed above. On the basis of different self-curing agent behavior with concrete, the synthetic and bio polymers which act as water sealer are more fruitful. A previous investigation shows that 5 % loss in water in concrete mixture leads to nearly 75 % loss in strength. Moreover, now a day the level of the water table is decreasing rapidly which tends to increase in its rate that leads to rise in the cost of construction work. Mostly used self-curing agents like lightweight aggregate, superabsorbent polymer, and wood powder have shown positive results in the reduction of self desiccation and autogenous shrinkage but also have the negative impact on strength and durability. In this study, experimental work was carried out to see the behavior of high volume fly ash concrete when self cured with synthetic polymer that is Polyethylene glycol and bio polymer Spinacia oleracea and effect of both self curing agent was also compared. For this study , the M30 concrete mix which was prepared by replacing cement 50%, 60%, 70%by weight with fly ash to make high volume fly ash concrete. The water-cement ratio was 0.36 for every concrete mixture. The different dosage considered for polyethylene glycol and Spinacia oleracea were 0.5 %, 1% and 0.5 %, 1% by weight of the binding material. Firstly the workability of self-cured high volume fly ash concrete was tested by using slump test method then compressive strength after different time period of 7 , 28 , and 56 days was also tested along with that the self cured high volume fly ash concrete durability was also tested and compared with each and with the sample which was normally cured.

III. MATERIALS

A. Cement

The cement used in the investigation was 53 grade ordinary Portland cement conforming to IS 12269 (BIS, 1987). The table below shows the basic properties of cement use.

TABLE 1. Properties of cement used

S.No.	Property	Description
1	Specific gravity	3.12
2	Specific surface	228 m^2 /g
3	Initial and final setting time	40 min, 600 min

B. Fine Aggregate and Course Aggregate

The fine aggregate conformed to Zone-2 according to IS 383 (BIS, 1970). The fine aggregate used was mine waste soil. Crushed granite was used as coarse aggregate. The coarse aggregate was obtained from a local crushing unit and had a nominal size of 20 mm; it was well-graded aggregate according to IS 383 (BIS, 1970).

TABLE 2. Properties of fine and coarse aggregate

S.No.	Property	Fine aggregate	Coarse aggregate
1	Specific gravity	2.64	2.75
2	Bulk density	1.45 g/cm^3	1.6 g/cm^3
3	Water absorption	1.5%	2.3%

C. Water

Potable water was used in the experimental work for both mixing and curing of normally specimens as per IS 3035.

D. Fly ash

Class F fly ash was used in this study, which was purchased from Dadri National Thermal Power Plant. It was light gray in color. Properties of fly ash are shown below.

Table 3 Fly ash properties

S.No.	Parameters	Fly ash
1.	Specific gravity	2.45
2.	Plasticity index	Non plastic
3.	Compaction factor MMD (gm/cc) OMC (%)	 0.90-1.60 38.00-18.00
4.	An angle of internal friction	35^0-40^0
5.	Cohesion (KN/$m^{2)}$	Negligible
6.	Compression index	0.05-0.4
7.	Permeability (cm/Sec)	10^{-3}-10^{-5}
8.	Particle size distribution Clay size fraction (%) Silt-size fraction (%) Sand size fraction (%) Gravel size fraction (%)	 1-11 7-85 6-90 0-10
9.	Coefficient if uniformity	3.2-10.4

E. Self-Curing Agents

Both types of polymer polyethylene glycol and biopolymer which are extracted from Spinacia oleracea was used in this study. Polyethylene glycol is actually a condensation polymer of ethylene oxide and water with the general formula H(OCH 2CH 2)n OH, where n is the average number of repeating oxyethylene groups. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. Polyethylene glycol is non-toxic, odorless, neutral,

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lubricating, non-volatile and non-irritating and is used in a variety of pharmaceuticals Spinacia oleracea is usually called as Palak or spinach in all over the world and it is a type of green popularly consumed as the food product. The curing agent was prepared from the filtrate extract of Spinacia oleracea after it was ground well.

Figure 1 Spinacia oleracea extracts

This extract base is added at the time of preparing concrete that is while adding water to the dry ingredients. Placing and compacting the fresh concrete is similar to the conventional concrete, but without curing. The chemical structure shows that it contains (-O-) and (-OH) functional groups. As such, the Spinacia oleracea selected as an internal curing agent possesses hydroxyl and ether functional group, which is also revealed in Fourier Transform Infra-Red (FTIR) results. The chemical and physical property of both is given in the table below. These Liquid was mixed in water which was used for preparing the concrete mixture [11]

Table 4 chemical and physical properties of PEG and SO

S.No.	Description	Polyethylene glycol	Spinacia Oleracea
1	Molecular weight	600 g/mol	500–1,000 g/mol.
2	Appearance	Clear fluid	Green fluid with small fibers
3	Solubility in water	Yes	Yes
4	pH	6	6.59
5	Specific gravity	1.12	1.1

IV. MIX PROPORTIONING AND NOMENCLATURE OF SPECIMENS

The sample was designated according to an amount of fly ash composition and on the basis of self-curing agent added to them. The M30 concrete mix is considered in which three different proportions of fly ash are added by replacing cement by weight. The ratio of each material that is cement, fly ash, sand and coarse aggregate will be calculated according to IS 10262:2009. The Mix design used was 1:1.45:2.7 with water cement ratio 0.36 for all samples. The Polyethylene glycol designated as 'P', Spinacia Oleracea as 'S' and normal water curing by 'N'. The percentage of both the self-curing agent was taken as 0 %, 0.5%, and 1 %. The concrete mixture containing 50%, 60%, and 70% fly ash was donated as 'A', 'B' and 'C'. So sample AP 0.5% represents that it contains 50 % fly ash with 0.5% of Polyethylene glycol. 'D' stands for durability sample.

V. EXPERIMENTAL WORK

The experimental work concern with the comparison of three different curing condition one which was normally cured, second with PEG and third with SO cured. The potency of the chosen compounds was compared on the basis of compressive strength and durability. These hydrophilic self-curing agents are supposed to reduce the evaporation of water and increase the water retention capacity for the hydration process. Slump test was also conducted on the freshly prepared mix to perceive the effect of both self-curing agents on the workability of concrete as per IS 1199 – 1959. The compressive strength of all samples was tested at 7, 28 and 56 days by casting cube of 150*150*150 mm size according to IS 516 – 1959. The durability of an acidic environment and an alkaline environment of the concrete cube was also checked which was cured under different conditions. The weight and the compressive strength of the specimens have been determined after keeping it in 5% solution of sulphuric acid for 28 days. Similarly, the alkaline resistance test was carried out on cube specimens by immersing in water diluted with 3% sodium hydroxide by weight of water for 28 days continuously. The beholding or retention capacity of self-curing agents was also monitored by weighing the cubes at regular intervals. Sample AS 0, AP 0, BS 0, BP 0, CS 0 and CP 0 were normally cured by keeping them in water as no self-curing agents were added to them.

VI. RESULTS AND DISCUSSION

A. Slump Test

Concrete must be workable so that it achieves a maximum density with a reasonable amount of compaction effort. If concrete is not workable or relatively less workable, it will not be compacted to its desired density resulting in less strength and porosity ultimately, so workability of all samples was checked. According to IS code 456, 2001, the medium workability that is 50mm was considered as the minimum workability for comparing the workability of self-cured concrete with the normally cured sample. From

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figure 2 and 3 we can see that all the sample has passed the benchmark of workability.

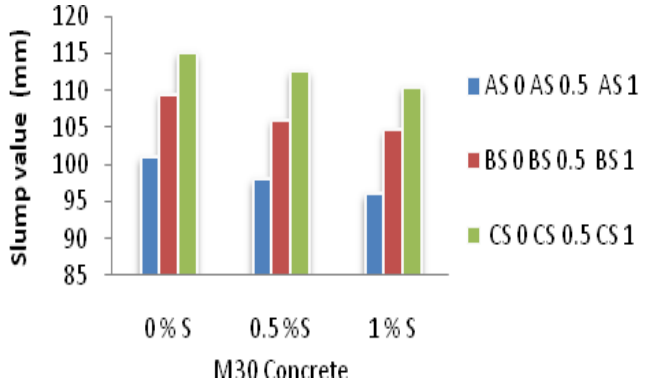

Figure 2 slump value of HVFA concrete with varying % of SO

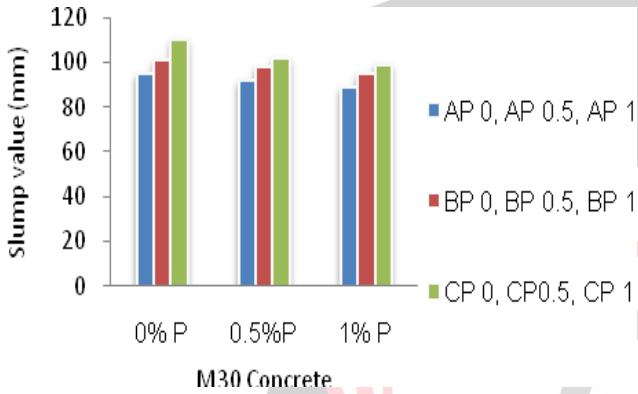

Figure 3 Slump value of HVFA concrete with varying % of PEG

B. Compressive Strength

Compressive strength was performed at 7 days, 28 days and 58 days for all the samples, with an average of three specimens for each curing period. The sample AS 0 ,BS 0, CS 0 ,AP 0,BP 0,and CP 0 have zero percentage of self curing agents were cure by normal curing and rest of the samples which have self curing agents were kept in shades after demoulding for respective days .The figures of compressive strength shows leisurely variation in strength because high volume fly ash concrete. But after a few days due to fly ash pozzolanic reaction take place, there is the great increase in strength at 56 days. With increase in the percentage of self curing agent from 0.5 to 1 % the amount of strength gain was increased .Sample cured with 1%of Spinacia oleracea which contained 50% fly ash shows the maximum strength as compared to PEG and normally cured sample. This was because of the presence of ether and hydroxyl compound present in it. Figure3, 4,5 show variation of the strength of concrete when cured with increasing percentage of SO self-curing agent and with the increasing percentage of fly ash in concrete. Similarly, figure 6,7and 8shows the effectiveness of PEG self-curing agent. The figure9 represent the 56-day compressive strength of the sample which was cured by 1% of securing agents

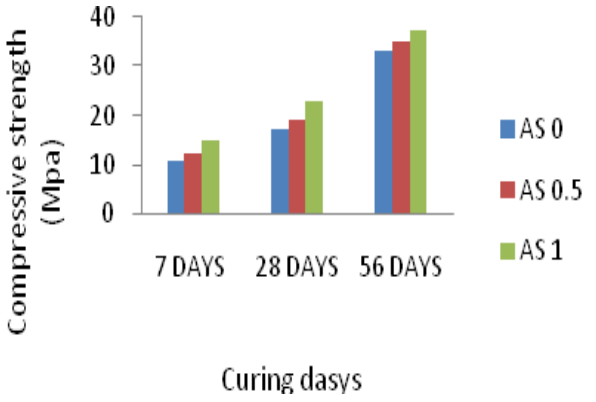

Figure 3 50% fly ash concrete compressive strength variation with days and % of SO

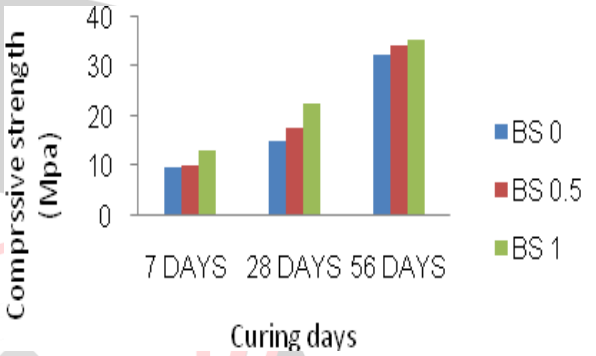

Figure4 60% fly ash concrete compressive strength variation with days and % of SO

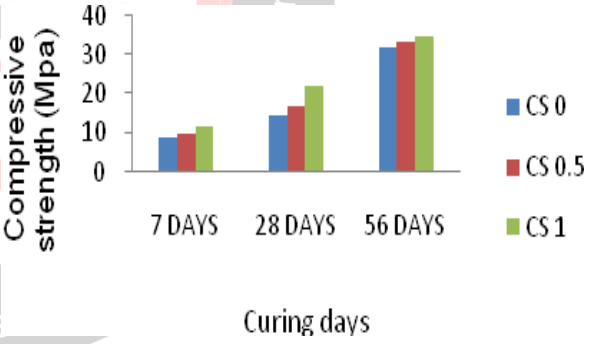

Figure5 70% fly ash concrete compressive strength variation with days and % of SO

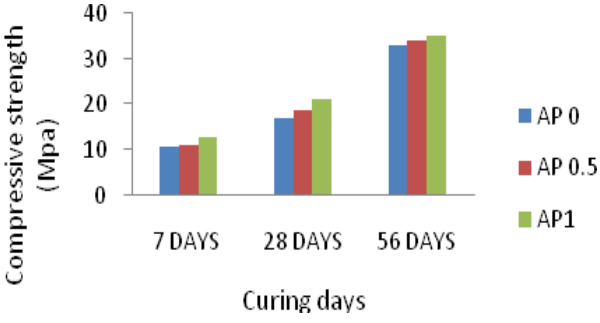

Figure6 50% fly ash concrete Compressive strength variation with days and % of PEG

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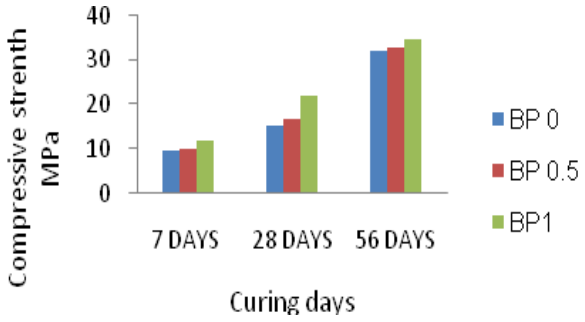

Figure 7 60% fly ash concrete Compressive strength variation with days and % of PEG

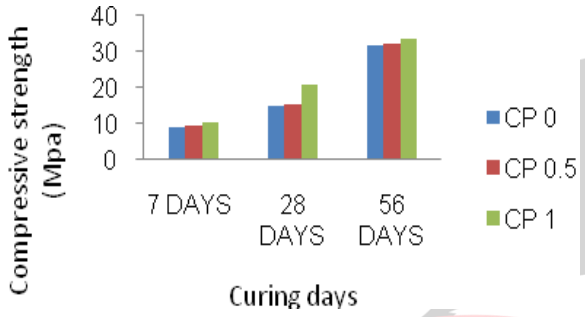

Figure8 70% fly ash concrete compressive strength variation with days and % of PEG

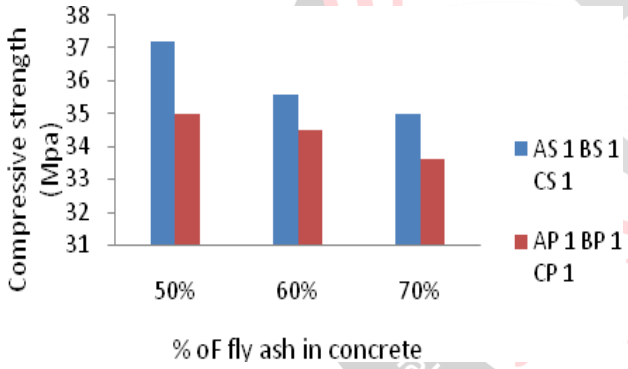

Figure 9 Comparison of 56day compressive strength cured with SO and PEG

C. Durability

The durability of samples was investigated it was observed that the percentage chance for the attack of concrete by acid and alkaline was reduced because of less pore structure of high volume fly ash concrete and the presence of self-curing agents. They make them watertight and does not allow further entry of chemical water. While considering loss of strength in percentage about 14% to 15% strength loss took place when the normally cured sample was kept in acid and alkaline water, whereas this percentage of loss of strength reduces for concrete which was cured by PEG. Spinacia oleracea shows the best result as there were only 1 % to 3% strength loss took place. . The figure 12,13 and 14 compares the strength of concrete cubes which are cured for 58 days and concrete cubes which was kept for durability check ,means cubes were cured first for 28 days same as compressive strength cubes and then kept in the chemical mix for more 28 days. The figures also show that with an increase in the percentage of fly ash loss of strength is also less as compared to less fly ash percentage concrete.

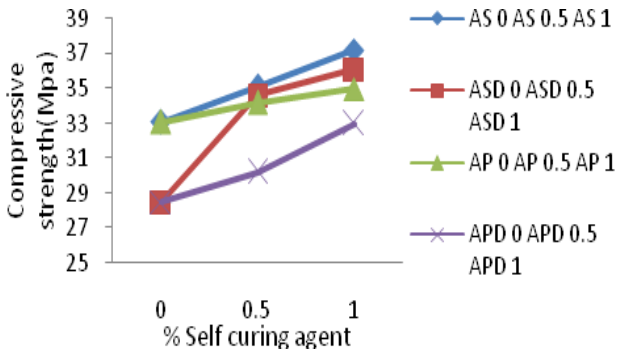

Figure 10 Comparing 56 days compressive strength AS,AP sample with ,APD and ASD samples

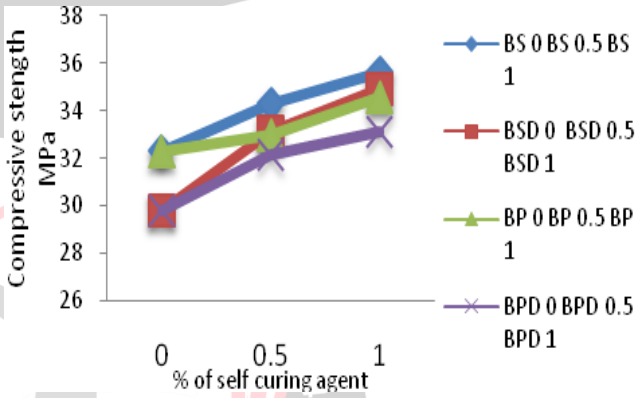

Figure 11 Comparing 56 days compressive strength BS,BP sample with ,BPDand BSD samples

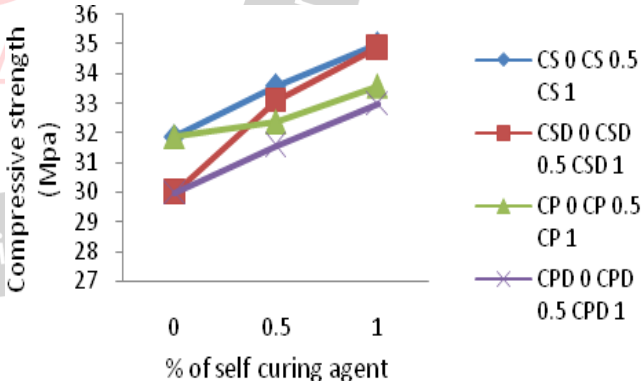

Figure 12 Comparing 56 days compressive strength, CS, CP sample with, CPD and CSD samples

VII. CONCLUSION

- The workability was slightly affected by the use of self-curing agent, but still, it satisfies the medium workability according to the standards. It's also visible from figure 2, 3 that Spinacia oleracea affect the concrete workability less as compare to the Polyethylene glycol.

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- The compressive strength of concrete cubes which were self-cured has the high strength by 2% to 4% as compared to normally cure concrete. The Spinacia oleracea show higher strength at 1%dosage than polyethylene glycol at same dosage. In figure 9, compressive strength high volume fly ash concrete after 56 day clearly represent that the water sealing power of Spinacia oleracea is more than Polyethylene glycol at same quantity.
- Acid resistance was also improved with use of self curing agents as loss of strength in percentage was around 2% for SO, 3 to 4% for PEG and more than 6% for normally cured.
- The study also shows that effectiveness of self-curing agents does not depend on the amount of fly ash added to concrete although totally depends on the percentage of dosages of self-curing agents.

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