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An Experimental Investigation on Compressive Strength of Self-Curing Concrete Incorporated With Polyethylene Glycol-400

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Abstract: ***The word concrete comes from the Latin word "concretus" (meaning compact or consolidated), the perfect passive participle of concrescere from "con" (together) and "crescere" (to grow).Today concrete is most widely used material in construction due to its good compressive strength and durability. The concrete is a composite construction material composed of cement (commonly Portland cement) and other cementious materials such as fly ash and slag cement, aggregates made up of gravels or crushed rocks like lime stone, granite, a fine aggregate (sand), water and chemical admixtures. Depending upon the nature of work, the cement, fine aggregates, coarse aggregates and water are mixed in specific proportions to make plain and fresh concrete. The strength and durability will develop fully if it is cured. Concrete is needed to be provided with moisture for minimum period of 28 days for good hydration to meet desired strength and durability requirement. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduce self-desiccation it was found that water soluble alcohols can be used as self curing agents in concrete. The use of self curing admixtures is very important from the point of view that water resources are getting valuable everyday. Polyethylene Glycol-400 is a one such self curing agent.***

Keywords: Self curing concrete, Internal curing, workability, compressive strength, polyethylene glycol.

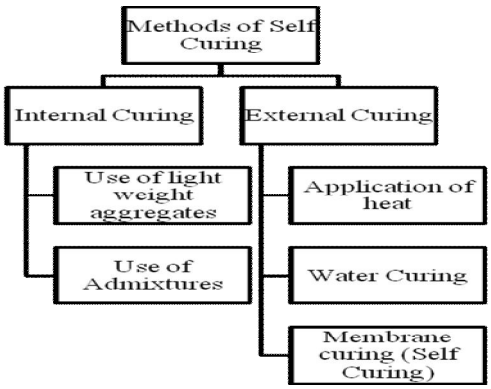
I. INTRODUCTION

Self curing is also referred as internal curing (IC). "Self curing refers to a process by which hydration of cement occurs because of availability to additional internal water that is not a part of mixing water".

Conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e. curing is taken to happen from outside to inside. In contrast, self curing is allowing the curing from inside to outside through internal reservoirs.

The following materials can provide internal water reservoirs

A. Light weight aggregates (Natural and synthetic)
B. LWS Sand (Water Absorption = 17%)
C. LWA 19 mm coarse (Water Absorption = 20%)
D. Super Absorbent polymers (SAP)
E. SRA (Shrinkage reducing admixture), i.e. polyethylene glycol
F. Wood Powder



1) Need for Self-Curing

a) Normal concrete lacks required strength and durability due to insufficient curing while after casting the concrete, curing plays a crucial role in construction.

b) So it is felt necessary to improve strength and durability of concrete by internal curing with suitable admixtures.

When the mineral admixtures react completely in a blended cement system, their demand for curing water (external o internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, due to depercolation of a capillary porosity, for example, significant autogeneous deformation and early age cracking may result.Due to chemical shrinkage occurring during cement hydration, empty pores are created in the cement paste, bleeding to a reduction in its internal relative humidity and also to shrinkage which may cost early age cracking. This situation is intensified in HPC (compared to conventional concrete) due to its generally higher cement content, reduced water/ cement (W/C) ration and the pozzolanic mineral admixtures (fly ash, silica fume). The empty pores created during self desiccation induce shrinkage stresses and also influence the kinetics of cement hydration process, limiting the final degree of hydration. The strength achieved by IC could be more than that possible under saturated curing conditions.

II. MECHANISM OF SELF CURING

Continuous evaporation of moisture takes place from an exposed surface due to difference in chemical potential (free energy) between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduced the chemical potential which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.

III. ADVANTAGES OF SELF-CURING

A. Internal curing is a method to provide the water to hydrate all the cement, accomplishing what the mixing water alone can not do, in low W/C ratio mixes absorptive light weight aggregate, replacing some of the sand, provides water that is desorbed in to the mortar fraction to be used as additional curing water.

B. Internal curing provide water to keep the relative humidty high.

C. Internal curing eliminates autogeneous shrinkage.

D. Internal curing maintains the strength of mortar at early age above the level where internally and externally induced strains can cause cracking.

E. Internal curing can make up some of the deficiencies of external curing, both human related and hydration related.

IV. SELF-CURING AGENT (POLYETHYLENE GLYCOL-400)

Polyethylene Glycol-400 (PEG) is a low molecular weight grade of polyethylene glycol. It is a clear, colourless, viscous liquid. The chemical formula for polyethylene Glycol is $C_{2n}H_{4n+2}O_{n+1}$.

It is mixed in concrete to enhance the strength. The polymers added in the mix mainly form hydrogen bond with water molecules and reduces the chemical potential of molecules of water which in turn reduces vapour pressure, thus reducing rate of evaporation from the surface.

Table 1
Physical and Chemical Properties of PEG 400

S.No.	Properties	Value
1	Colour	Colourless
2	Odour	Mile Odour
3	Density	1.128 g/cm^2
4	Solubility	Soluble in Water
5	Molar Mass	380-420 g/mol

V. AIM OF INVESTIGATION

The aim of investigation is to study the strength and durability properties of concrete using water soluble polyethylene glycol as self-curing agent. The function of self-curing agent is to reduce the water evaporation from concrete, and hence they increase the water retention capacity of concrete compared to conventionally cured concrete. The use of self-curing admixture is very important from the point of view that saving of water is a necessity everyday. In this study, compressive strength and workability of concrete

containing self-curing agent is investigated. It is found through experimental investigation that concrete casted with polyethylene glycol-400 as self-curing agent is stronger than that obtained by sprinkler curing as well as by immersion curing.

VI. MATERIALS USED AND METHODOLOGY

A. Cement

Cement, ordinary Portland cement of grade 43 was used, with following physical properties: -

Characteristics	Value
Specific Gravity	3.10
Consistency (%)	33%
I.S. Time	105 mins.
F.S. Time	260 mins

B. Aggregates

20 mm size of aggregates was used as coarse aggregates and 4.75mm size of aggregates was used as fine aggregates as per I.S. 383 : 1970.

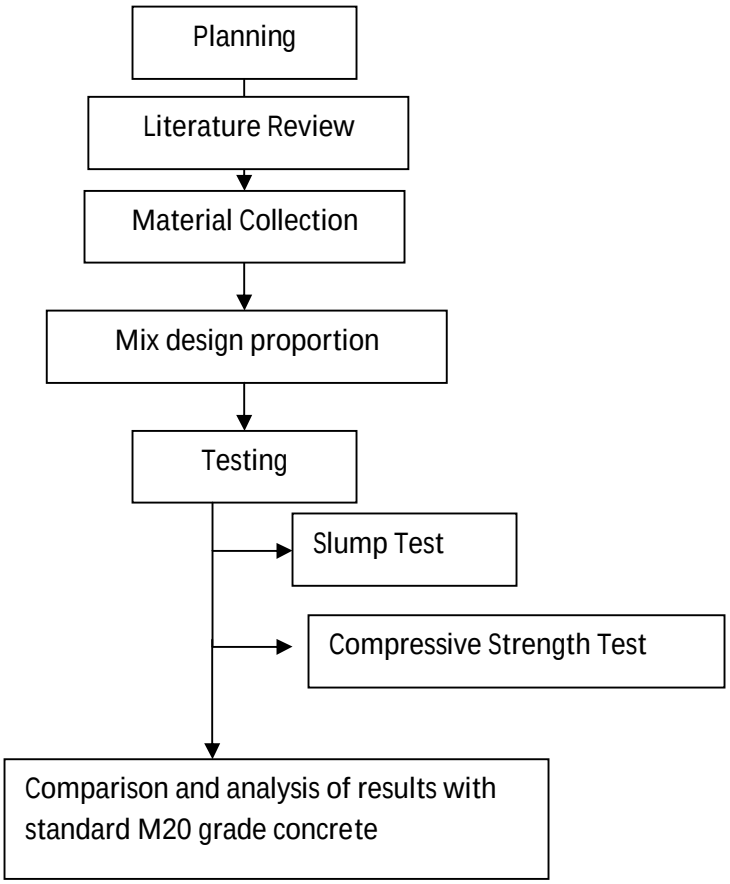
C. Polyethylene Glycol 400

Polyethylene Glycol-400 (PEG) is a low molecular weight grade of polyethylene glycol. It is a clear, colourless, viscous liquid. The chemical formula for polyethylene Glycol is $C_{2n}H_{4n+2}O_{n+1}$.The general formula of PEG with water is $H(OCH_2CH_2)nOH$. Polyethylene glycl has mol. wt. of 450, appearance clear, pH 5-7 and specific gravity of 1.126.

D. Water

Clean and portable water was used for mixing and curing.

E. Methodology



VII. SPECIMEN PREPARATION AND EXPERIMENTAL INVESTIGATION

It was done to investigate the strength of self-curing concrete by adding polyethylene glycol (PEG-400) at 0%, 0.5%, 1%, 1.5%, 2% by weight of cement to concrete. It was aimed to study compressive strength of M20 grade concrete. The scheme is given in table: -

Sr. No.	Concrete Mix M20	Workability & Compressive Strength Test	
	Mould size	15×15×15 cm cube	
	Days	7 Days	28 Days
A	With general curing and without admixture	3	3
B1	With admixture PEG-400 0.5% weight of cement	3	3
B2	With admixture PEG-400 1% weight of cement	3	3
B3	With admixture PEG-400 1.5% weight of cement	3	3
B4	With admixture PEG-400 2% weight of cement	3	3

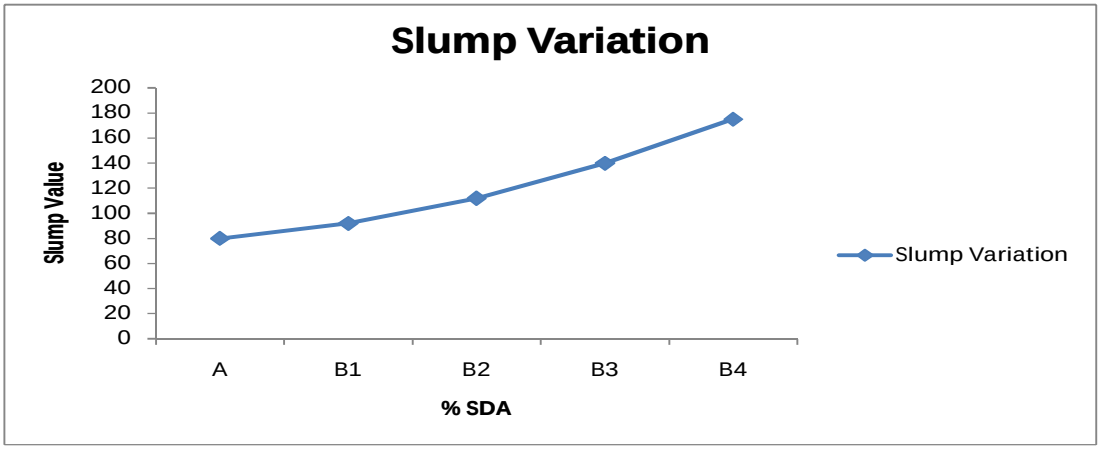
Mix design of concrete was prepared as per IS 456:2000. Casting of material was made as per IS 10086:1982. The mixing and compacting of concrete was done as per IS 516:1959. The plain samples of cubes were cured for a day in water pond and specimen with PEG-400 were cured for 1 day at room temperature. The following table shows the material required per cubic meter of concrete: -

Mix	Water (KG)	Cement (KG)	F.A. (KG)	C.A. (KG)
M20	180	360	584	1223.8

A. Slump test and values

To the find the consistency of concrete, slump test is the best method. It can be done in lab as well as in field. It is performed on fresh concretes. The table shows slump value variation with %age of PEG-400 used.

Concrete Mix	M20 Slump Value (mm)
A	80
B1	92
B2	112
B3	140
B4	175

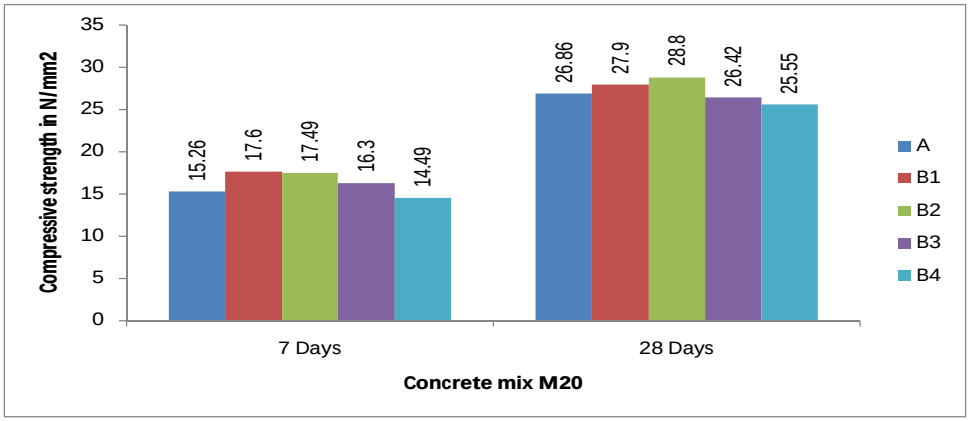


From these results it was notified that concrete becomes more workable as PEG-400 %age is increased that means less water is required to make mix more workable.

B. Compressive Strength test and values:

For this study, several cubes of size 15×15×15 cm were tested of design mix M20 grade. The specimen were tested after curing period of 7 and 28 days on compression testing machine of capacity 2000 KN. The bearing surface was wiped off clean and specimen was placed and load was applied on sides rather than top and bottom. The results of compressive strength test are shown in table: -

Concrete Mix	Average Compressive Strength(N/mm^2)	
	7 days	28 days
A	15.26	26.86
B1	17.6	27.90
B2	17.49	28.80
B3	16.3	26.42
B4	14.49	25.55



The table and graph shows the variation in compressive strength of M20 grade concrete with 0.5%, 1%, 1.5% and 2%, PEG-400 by weight of cement.

VIII. IMPROVEMENTS IN CONCRETE DUE TO INTERNAL CURING

A. Reduces autogenous shrinkage
B. Reduces permeability
C. Protects reinforcing steel
D. Increases mortar strength
E. Increases early age strength and durability
F. Increases early age compressive strength
G. Lower utilization of cement
H. Lower maintenance
I. Higher performance
J. Reduces effect of insufficient external curing.

IX. CONCLUSION

A. The workability of concrete mix is increased upto greater extent by addition of PEG-400 at different %ages by weight of cement.
B. The 0.5%, 1%, 1.5% polyethylene glycol incorporated concrete have high compressive strength at 7 and 28 days as compared to conventional M20 grade concrete.
C. The 2% polyethylene glycol incorporated concrete have low compressive strength at 7 and 28 days as compared to conventional M20 grade concrete.

D. The optimum dosage of PEG-400 for maximum compressive strength was found to be 1% by weight of cement of M20 grade concrete.

E. Internal curing by addition of PEG-400 is an effective means of reducing autogeneous shrinkage, cracking, reduces permeability, increases mortar strength and early age strength. Since autogeneous shrinkage is a main contributor to early age cracking. It is expected that internal curing will also reduced such cracking.

F. Self-curing concrete is the best solution to the problem faced in desert region and faced due to lack of proper curing.

X. ACKNOWLEDGEMENT

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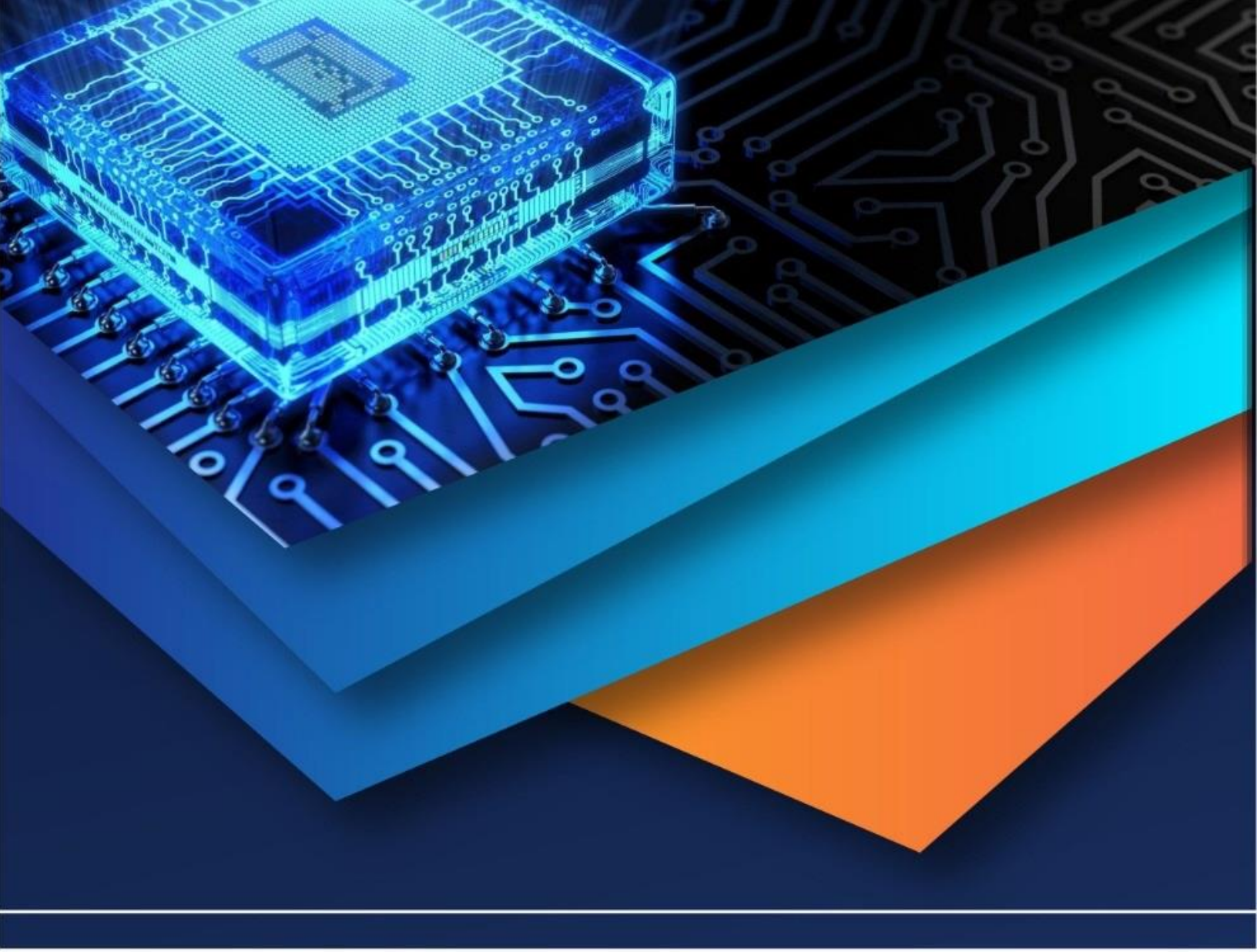

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