IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X,
PP 12-17
www.iosrjournals.org

Studies On Properties Of Self-Curing Concrete Using Poly-Ethylene Glycol

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Abstract: *Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However good curing is not always practical in many cases. Therefore the need to develop self-curing agents attracted several researchers. The concept of several self-curing agents to reduce water evaporation from concrete. And hence increase the water retention capacity of concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in concrete construction in the new millennium .The aim of this investigation is to evaluate the use of water-soluble polymeric glycol as self-curing agents. the use of self-curing admixture curing admixtures is very important from the point of view that the water resources are getting valuable every day(ie; each 1 m3 of concrete require about 3 m3 of water for construction. Most of which is for curing). The benefit of self -curing admixtures is more significant in desert areas where water is not adequately available. In this study the mechanical properties of self-curing at different percentages of poly ethylene glycol will be evaluated and compared with conventional concrete specimen.*
Keywords - *Bulk water,PEG, Polyelectrolyte ,SAP,Sorption isotherm*

I. Introduction

Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80%. Proper curing of concrete structures is important to meet performance and durability requirements. 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 reduced self-desiccation. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Curing temperature is one of the major factors that affect the strength development rate. At elevated temperature ordinary concrete losses its strength due to the formation of the cracks between two thermally incompatible ingredients, cement paste and aggregates.

1.2 Mechanism And Significance Of Self Curing Concrete

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (Free energy) between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, significant autogenous deformation and (early-age) cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking.

1.3 Potential Materials For Internal Curing (IC)

The following materials can provide internal water reservoirs:

  Lightweight Aggregate (natural and synthetic, expanded shale)
  Super-absorbent Polymers (SAP) (60-300 nm size)
  SRA (Shrinkage Reducing Admixture) (propylene glycol type i.e. polyethylene-glycol)

II. Need And Scope Of Study

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However good curing is not always practical in many cases. The aim of this investigation is to evaluate the use of water-soluble polymeric glycol as self-curing agents. The use of self-curing admixture curing admixtures is very important from the point of view that the water resources are getting valuable every day. The benefit of self -curing admixtures is more significant in desert areas where water is not adequately available .In this study the mechanical properties of self-curing at different percentages of poly ethylene glycol will be evaluated and compared with conventional concrete specimen.

Scope of the study is to identify the effect of polyethylene glycol (PEG) on strength characteristics of self-curing concrete and also to evaluate influence of poly ethylene glycol on mechanical properties which are experimentally investigated.

2.1 Objective

  To study the mechanical characteristic of concrete i.e., compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG from 0% to 1.5% by weight of cement for both M25 grade of concrete.
  To attain the optimum percentage of PEG.
  To study the mechanical properties of concrete mix by varying percentage of chemical admixture.

III. Super-Absorbent Polymer (S A P) For Internal Curing

The common SAPs are added at rate of 0–0.6 wt. % of cement. The SAPs are covalently cross-linked. They are Acrylamide/acrylic acid copolymers. One type of SAPs are suspension polymerized, spherical particles with an average particle size of approximately 200 mm; another type of SAP is solution polymerized and then crushed and sieved to particle sizes in the range of 125–250 mm. The size of the swollen SAP particles in the cement pastes and mortars is about three times larger due to pore fluid absorption. The swelling time depends especially on the particle size distribution of the SAP. It is seen that more than 50% swelling occurs within the first 5 min after water addition. The water content in SAP at reduced RH is indicated by the sorption isotherm.

3.1 Polyethylene Glycol

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula $H(OCH_2CH_2)_nOH$, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. One common feature of PEG appears to be the water-soluble nature. Polyethylene glycol is non-toxic, odorless, neutral, lubricating, non-volatile and non-irritating and is used in a variety of pharmaceuticals

Fig.3.1: Poly ethylene glycol

TABLE 3.1 Properties of PEG(400)

Sl.No.	DESCRIPTION	PROPERTIES
1.	MOLECULAR WEIGHT	400
2.	APPEARANCE	CLEAR FLUID
3.	MOISTURE	0.2%
4.	pH	6
5.	SPECIFIC GRAVITY	1.12

IV. MIX Proportion Designations

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

V. Study On Mechanical Properties

The casting of specimens were done as per IS 10086-1982, Preparation of materials. Weighing of materials and casting of cubes, cylinders, beams. The weighting, compacting, and curing of concrete are done according to IS: 516-1959. The plain samples of cubes, cylinders and cubes were cured 28 days in water pond and the specimens with PEG 400 were cured for 28 days at room temperature by placing them in shade. The M25 grade of concrete are designed

TABLE 5: Casting intakes

Ingrediens	UNIT	A	B	C	D
Water	$1/m^3$	191.6	191.6	191.60	191.60
Cement	Kg/m^3	426	426	426	426
Fine Aggregate	Kg/m^3	498	498	498	498
Coarse Aggregate	Kg/m^3	1361.80	1361.80	1361.80	1361.80
Water Cement-Ratio	By mass	0.45	0.45	0.45	0.45
Poly-Ethylene Glycol	%	0	0.5	1	1.5
Poly Ethylene Glycol	l/m^3	0	2.13	4.26	6.39

A=Concrete with 0% Poly-Ethylene Glycol :B=Concrete with 0.5% Poly –Ethylene Glycol :C=Concrete with 1% Poly-Ethylene Glycol :D=Concrete with 1.5% Poly-Ethylene Glycol.

5.1compressive Strength

The cube specimens were tested on compression testing machine of capacity 3000KN.The bearing surface of machine was wiped off clean and sand or other material removed from the surface of the specimen. The specimen was placed in machine in such a manner that the load was applied to opposite sides of the cubes as casted that is, not top and bottom. The axis of the specimen was carefully aligned at the center of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded.

$F_c = P/A$, (1)

where, P is load & A is area. Following graph shows the variation in compressive strength with addition of PEG.

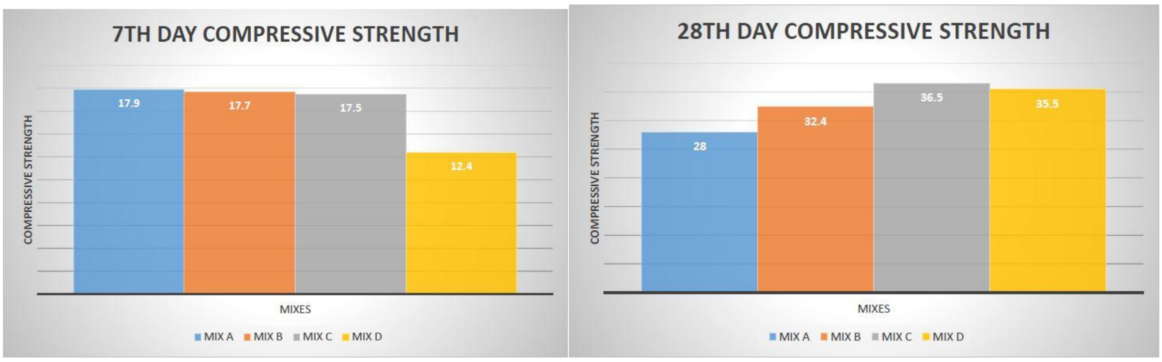

Fig.5.1:7 day and 28 day compressive strength variation with 0-1.5% PEG

5.2 Split Tensile Strength

The cylinder specimens were tested on compression testing machine of capacity 3000KN.The bearing surface of machine was wiped off clean and looses other sand or other material removed from the surface of the specimen. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded.

fsplit =2 P/πD, (2)
where P=load, D= diameter of cylinder, L=length of the cylinder.
Following graph shows the variation of split tensile strength with addition of PEG.

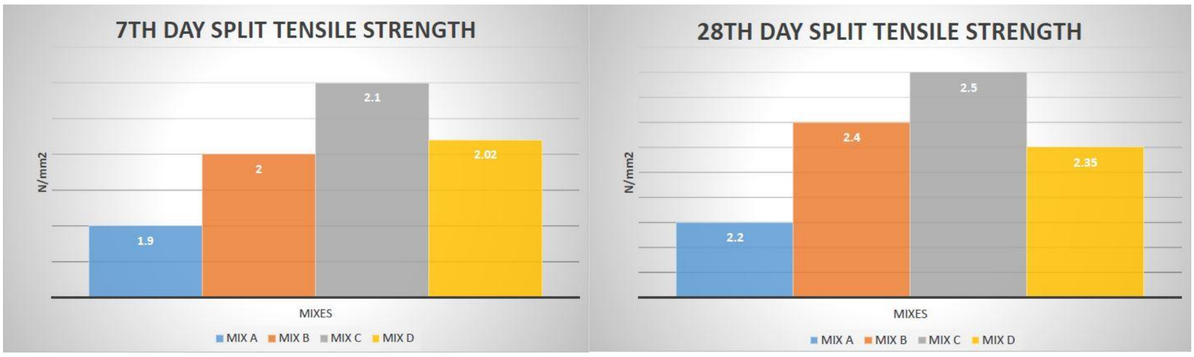

Fig.5.2: 7day and 28 day split tensile strength variation with 0-1.5% PEG

5.3 Modulus Of Rupture

The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded.

$f_{Rup} = (WL)/(bd^2)$, (3)
Where,
W = load at failure
L = length of specimen (700mm)
b = width of specimen (150mm)
d = depth of specimen (150mm)
when ‘a ’is greater than 20.0cm for 15.0 cm specimen ,in cm ,or greater than 13.3 cm for a 10.0 cm specimen, (4)

Or when ‘a’ is less than 20.0 but greater than 17.0 cm for 15.0 specimen or less than 13.3 cm but greater than 11.0cm for a 10.0cm. Following graph shows the variation in flexural strength with addition of PEG.

Fig.5.3: 7day and 28 day flexural strength variation with 0-1.5% PEG

VI. Inference On Mechanical Properties And Workability

The mechanical properties mainly deal with compressive strength, split tensile strength & flexural strength. Firstly we are dealing with the compressive strength, as we told above we just use used four different proportions of polyethylene glycol. ie, (0%,0.5%,1%&1.5%) ,when we conducted the 7th day compressive strength it is noticed that the value just get increased by the varying proportion & then a sudden decrease in the strength as shown in the graph & we found that 1% was optimum as shown in the graph. Next we just deal with the 28th day strength and the values get increased by the proportions and we get maximum strength for 1%, & then we noticed a sudden decrease in the value for 1.5%.

After that modulus of rupture is determined, here also we are in action with the same proportions of PEG, when we just noticed the 7th day flexural strength it is noticed that the values just get increased by the proportions & found an optimum value in 1% as clearly shown in the graph and then a decrease in value for mix-d. As well as concerned about the 28th day strength the values get increased by proportions and gained a maximum value for 1% as shown, & then a slight decrease in value for mix-d.

Then the split tensile strength is determined and the same step is followed for determining the 7th as well as 28th day strength is computed. While we checked the value for 7th day& 28th day strength, it is noticed that the values get increased by different proportions and obtained an optimum value of 1%.

As a result of slump test it is noticed that the value for the four mixes gets increased by different percentage with a maximum slump for 1.5%, but the correct value belongs to 1%, (98mm) as shown in the graph.

As far as concerned about the compaction factor test, the result obtained after conducting test is that, the compaction factor value just increases by varying percentage as shown in the graph.It is evident that highest value is highlighted for mix-D, but the optimum range stands for mix-c (1%) as clearly depicted in the graph.

VII. Conclusion

- The optimum dosage of PEG400 for maximum strengths (compressive, tensile and modulus of rupture) was found to be 1%
- If dosage exceeds 1% there is a slight decrease in the strengths mentioned above.
- As percentage of PEG400 gets increased slump as well as compaction factor also gets increased.
- Strength of self-curing concrete is relatively high when compared with conventional concrete.
- Self-curing concrete is the viable answer to many problems faced due to lack of proper curing.
- Self-curing concrete is an alternative to conventional concrete in desert regions where scarcity of water is a major problem.

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