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# A STUDY ON PROPERTIES ON SELF CURING CONCRETE

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**Abstract:** Concrete requires curing to continue with the hydration process. Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete. The present study involves the use of polyethylene glycol which acts as a self-curing compound. The most important aspect is that this compound is expected to maintain maximum water retention there by contributing to full hydration. The parameters in the study include grade of concrete, type and dosage of polyethylene glycol, curing conditions and age of curing. The present involves the two types of self-curing compounds PEG 4000, PEG 200 with dosage of 0.1%, 0.5%, 1% for M70 grade of concrete. Weightless and compressive strength, flexural strength and durability tests were determined as a performance benchmark for the investigated curing compounds. It was reported from the study that higher dosage (1%), higher molecular weight (4000) based PEG compounds act as better curing compounds in higher grade concretes compared to another self-curing compound.

***Keywords*** *-self curing, Polyethylene glycol, PEG 4000, PEG 200, Hydrophilic compound, Water retention, Compressive strength, flexural strength, durability tests.*

## 1.INTRODUCTION

A. Curing

Adequate curing is essential for concrete to obtain structural and durability properties and therefore is one of the most important requirements for optimum concrete performance. Curing of concrete is the process of maintaining the proper moisture conditions to promote optimum cement hydration immediately after placement. With insufficient water, the hydration will not proceed and the resulting concrete is practically affected, failing to provide a protective barrier against ingress of harmful agents. Proper curing of concrete structures is important to meet performance and durability requirements. Enough water needs to be present in a concrete for the hydration of cement to take place. However, even mix contains enough water, any loss of moisture from the concrete will reduce the initial water cement ratio and result in incomplete hydration of cement especially with the mixes having low water cement ratio. This results in very poor quality of concrete.

Methods of Conventional Curing:

Methods of curing concrete fall broadly into the following categories:

i) Ponding or spraying
ii) By using covering of wet hessian.

iii) Reducing the rate of evaporation of water from concrete surface by covering with a relatively impermeable membrane.
iv) Delaying the removal of formwork can also be used to retain some water.
v) Steam curing.

Difficulties in conventional curing methods:

i) For the vertical member it is not possible to keep the surface moist as in case of the flat surfaces.
ii) In the places where there is scarcity of water.
iii) In the places where manual curing is not possible.
iv) A human error may lead to the formation of crack in the member and hence affects strength and durability.

B. Self Curing Concrete

The concept of self curing agents is to reduce the water evaporation from concrete and hence increase the water retention capacity of the 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 represents a new trend in the concrete construction in the new millennium. Curing of concrete plays, a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day(i.e., each 1cu.m of concrete requires about 3cu.m of water for construction most of which is for curing). Excessive evaporation of water (internal or external) from fresh concrete should be avoided; otherwise, the degree of cement hydration would get lowered and there by concrete may develop unsatisfactory properties. Curing operations should ensure that adequate amount of water is available for cement hydration to occur. This investigation discusses different aspects of achieving optimum cure of concrete without the need for applying external curing methods. The effect of curing, particularly new techniques such as "self-curing", on the properties of high performance concrete is primary importance to the modern concrete industry.

Definition of Self Curing:

The ACI-308 Code states that "internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the 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 the outside to inside'. In contrast, 'internal curing' is allowing for curing 'from the inside to outside' through the internal reservoirs (in the form of saturated light weight aggregates, superabsorbent polymers, or saturated wood fibers) created. 'Internal curing' is often referred as 'Self-Curing'. "Self-curing concrete" means that no labour work is required to provide water for concrete, or even know any external curing is required after placing which the properties of this concrete are at least comparable to and even better than those of concrete with traditional curing.

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Self-Curing is an "internal curing system" where a water-soluble polymer is added to the concrete mix. This method overcomes the difficulty in ensuring that effective curing procedures are employed by the construction personnel as the internal curing composition is a component of the mix.

Why to do Self-curing:

A self-curing concrete is provided to absorb water from atmosphere to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete.

Need for Self-curing:

When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than 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 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. This situation is intensified in HPC (compared to conventional concrete) due to its generally higher cement content, reduced water-cement(w/c) ratio and the pozzolonic mineral admixtures (fly-ash, silica fume).

Potential materials for self curing:

The following materials can provide internal water reservoirs:

i) Light-Weight Aggregate (natural and synthetic, expanded shale).
ii) Super Absorbent Polymers (SAP) (60-300mm size).
iii) LWA (light weight aggregate) 19mm coarse (Water absorption = 20%).
iv) LWS (light weight sand) sand (Water absorption = 17%).
v) SRA (Shrinkage Reducing Admixture).
vi) Wood powder.

C. Polyethylene glycol

Polyethylene glycol (PEG), otherwise known as polyoxymethylene or poly ethylene oxide (PEO), is a synthetic polyether that is readily available in a range of molecular weights. Materials with $M_w$ <100,000 are usually called PEGs, while higher molecular weight polymers are classified as PEOs. These polymers are amphilic and soluble in water as well as in many organic solvents (e.g., methylene chloride, ethanol, toluene, acetone, and chloroform). Low molecular weight ($M_w$ <1,000) PEGs are viscous and colourless liquids, while higher molecular weight PEGs are waxy, white solids with melting points proportional to their molecular weights to an upper limit of about 67°C. PEG and PEO are liquid of low melting solids, depending on their molecular weight. PEGs are prepared by polymerization of ethylene oxide and are commercially available over a wide range of molecular weights from 300g/mol to 10,000,000g/mol.

PEGs are also available with different geometries.

i) Branched PEGs have three to ten PEG chains emanating from a central core group.

ii) Star PEGs have 10 to 100 PEG chains emanating from a central core group.
iii) Comb PEG s have multiple PEG chains normally grafted onto a polymer backbone.
The numbers that are often included in the names of PEGS indicate their average molecular weights ( e.g. a PEG with n=9 would have an average molecular weight of approximately 4000 Daltons, and would be labelled PEG 4000.

PEG is soluble in water, methanol, ethanol, acetonitrile, benzene, and dichloromethane, and is insoluble in diethyl ether and hexane. It is coupled to hydrophobic molecules to produce non-ionic surfactants.

D. Super plasticizer (BASF Glenium B233)

BASF glenium B233 is a super plasticizing admixture. Glenium B233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. Glenium B233 is free of chloride & low alkali and compatible with all types of cements. Glenium B233 consists of a carboxylic ether polymer with long side chains. At the beginning of the mixing process, it initiates the same electrostatic dispersion mechanism as the traditional super plasticizers, but the side chains linked to the polymer backbone generates a steric hindrance which greatly stabilizes the cement particles ability to separate and disperse. With this process, flow able concrete with greatly reduced water content is obtained.

**2. OBJECTIVE**

a) To develop mix design methodology for mix 70MPa
b) To study the effect of self-curing compound and its dosage on fresh properties concrete.
c) To determine the water retention capacity of all mixes by measuring weight loss of cubes at 3, 7,10, 14, 21, 28 days.
d) To determine the compressive strength of cubes at 7, 14, 28 days.

**3. MATERIALS USED**

Cement:

Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS : 12269 – 1987.

Fine Aggregate:

The fine aggregate used was obtained from a nearby river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

Coarse aggregate:

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

Polyethylene glycol (PEG):

Polyethylene glycol of low molecular (200) and high molecular weight (4000) were used in the study. The chemicals were mixed with water thoroughly prior to mixing of water in concrete.

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BASF glenium B233:

BASFglenium B233 is a super plasticizing admixture. Glenium B233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required.

## 4. EXPERIMENTAL WORK

Mix design:

| S.No | Item name | As per mixed design(kg/m3) |
|---|---|---|
| 1 | Cement | 520 |
| 2 | Fine aggregates | 782 |
| 3 | Coarse aggregates | 992 |
| 4 | water | 156 |
| Mix proportion is 1:1.503:1.907 | | |

Table .1: Designed Values of Materials (M70)

For M70 grade of concrete number of trails were conducted to obtain the desired strength and to maintain good workability (slump of about 50mm) and finally acquired a mix proportion (1:1.3:2.1) (C: F.A:C. A) with w/c ratio of 0.32. To obtain good workability and desired strength the optimum water-cement ratio kept at 0.32 and 0.3% of super-plasticizer is to be used in the mix.

A. Test for Fresh Properties of Concrete

Workability Test (Slump test):

Slump test is the most commonly used method of measuring workability of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability.

B. Test for Harden Properties of Concrete

Water Retentivity Test:

Water retentivity is the ability of the substance to retain water. To perform the water retentivity test, the cubes were weighed for every 3 days from the date of casting. Weight loss for the specimens in indoor curing, and weight gain for the conventional curing are noted and their behaviour is plotted in graph against number of days of curing.

Compressive Strength of Concrete:

The compression test was conducted according to IS 516-1959. The compressive strength was obtained after 7, 14 and 28 days of curing. Standard cast iron moulds of dimensions 150x150x150mm were used to cast the specimen. Material required for casting is given in Table 2& 3.

| S. No | Nomenclature Of Mix | No. Of Cubes | Cement (Kg) | Glenium B233(ml) | FA (Kg) | CA (Kg) | Water (lt) | Polyethylene glycol (gm) |
|---|---|---|---|---|---|---|---|---|
| 1 | Air curing (P-4000-0%) | 9 | 18.18 | 5.4 | 23.63 | 38.17 | 5.81 | 0 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | Water curing (P-4000-0%) | 9 | 18.18 | 5.4 | 23.63 | 38.17 | 5.81 | 0 |
| 3 | P-4000-0.1% | 9 | 18.17 | 5.4 | 23.63 | 38.17 | 5.81 | 18.18 |
| 4 | P-4000-0.5% | 9 | 18.09 | 5.4 | 23.63 | 38.17 | 5.81 | 90.9 |
| 5 | P-4000-1% | 9 | 18 | 5.4 | 23.63 | 38.17 | 5.81 | 181.8 |

Table.2 Material quantities of PEG 4000

| S.No | Nomenclature Of Mix | No. Of Cubes | Cement (Kg) | Glenium B233(ml) | FA (Kg) | CA (Kg) | Water (lt) | Polyethylene glycol (gm) |
|---|---|---|---|---|---|---|---|---|
| 1 | Air curing(P-200-0%) | 9 | 18.18 | 5.4 | 23.63 | 38.17 | 5.81 | 0 |
| 2 | Water curing(P-200-0%) | 9 | 18.18 | 5.4 | 23.63 | 38.17 | 5.81 | 0 |
| 3 | P-200-0.1% | 9 | 18.17 | 5.4 | 23.63 | 38.17 | 5.81 | 18.18 |
| 4 | P-200-0.5% | 9 | 18.09 | 5.4 | 23.63 | 38.17 | 5.81 | 90.9 |
| 5 | P-200-1% | 9 | 18 | 5.4 | 23.63 | 38.17 | 5.81 | 181.8 |

Table.3 Material quantities of PEG 200

Flexural Strength of Concrete (IS:516-1959):

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. The modulus of rupture depends on where the specimen breaks along the span. Beam dimensions are 500mm×100mm×100mm. if the specimen breaks at the middle third of the span then the modulus of rupture is given by

$$f_{rup} = \frac{Pl}{bd^2}$$

Where; P=load, d = depth of the beam, b = width of the beam.

C. Durability Studies on Concrete

Acid Attack Factor Test:

The chemical resistance of the concrete was studied through chemical attack by

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immersing them in an acid solution. After 28 days curing period of the specimens of each batch were taken and their surfaces were cleaned with soft nylon brush to remove weak reaction products and loose material from the specimen. The initial mass, body diagonal dimensions value were measured. 2 specimens of each batch of concrete were immersed in 5% HCL.

Figure.1 cube immersed in 5% HCL

Preparation of 5% HCL for 4lt solution:

$C_1V_1 = C_2V_2$

Concentration of HCL $C_1$= 36%

Required concentration of solution $C_2$= 5%

Volume required $V_1$= 4lt

Volume of HCL $V_2 = \frac{C2V2}{C1} = \frac{5*4}{36}$ = 555 ml

i.e., to prepare 4litres solutions of 5% HCL, the volume of HCL to be added is 555 ml.

The mass, diagonal dimensions values are measured at 3, 7, 10, 14, 21, 28 days of immersion. Compressive strength is measured after 28 days of immersion before testing, each specimen is removed from the baths, brushed with a soft nylon brush and rinsed in tap water. This process removes loose surface material from the specimens. Mass change, reduction in compressive strengths values and diagonal dimensions are observed. The extent of deterioration at each corner of the struck face and the opposite face is measured in terms of the acid diagonals (in mm) for each of two cubes and the "Acid Attack Factor" (AAF) per face is calculated as follows.

$$AAF = \frac{\text{loss in mm}}{4}$$

Acid Durability Factor Test:

For determining the resistance of concrete specimens to aggressive environment such as acid attack, the durability factors as proposed by the philosophy of ASTM (666-1997). In the present investigation, the "Acid Durability Factors" are derived in terms of relative strengths. The relative strengths are always compared with respect to the 28 days value (i.e., at the start of the test).

The "Acid Durability Factors" (ADF) can be calculated as follows.

$$ADF = \frac{S_r N}{M}$$

Where, Sr - Relative Strength at N days, (%), N - Number of days at which the durability factor is needed, M - Number of days at which the exposure is to be terminated. So M is 28 in this case.

## 5. RESULTS & DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

A. Slump Test:

The slump test is performed to know about workability. The plot of the slump test values for different dosages of PEG is shown in Table 4 & Figure 2. The following are the observations on slump test.

a. It is been observed that in case of specimens with PEG 4000 of 1% is less compared to other dosages (0.1%, 0.5%).

b. It is been observed that in case of specimens with PEG 200 of 0.1% is less compared to other dosages ( 0.5%, 1%).

| Percentage dosage of PEG | 0.1% | 0.5% | 1% |
|---|---|---|---|
| PEG 4000 | 52mm | 53.6mm | 50mm |
| PEG 200 | 50mm | 55mm | 58mm |

Table.4 Slump test values for different dosages of PEG

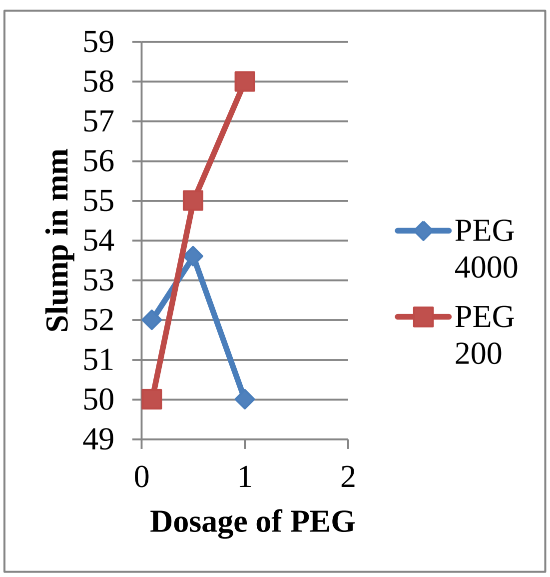


Figure.2 Variation of PEG with slump

B. Water Retention Test

a) Water Retention Test Results of PEG 4000:

Concrete with high molecular weight polyethylene glycol subjected to indoor curing was studied by weighing the samples at regular intervals of 3 days, with digital weighing of accuracy 5 gm up to 28 days. The results were recorded in Table 5. The plot of weight loss and average weight loss with different percentage of polyethylene glycol is shown in Figure 3. The following are the observations of water retentivity of concrete.

- it is clearly observed that the specimen without self curing agent i.e., in air curing losing more weight when compared to specimens with dosage of 0.1%, 0.5%, 1% of self curing agent.
- It is also been observed that in case of specimens with self curing agent of PEG 4000-0.5% dosage the weight loss is more when compared to other dosages ( 0.1%, 1%) of self curing agent.

| AVERAGE WEIGHT LOSS OF CUBES AT DIFFERENT AGES (gms) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nomenclature of mix | 0 days | 3 days | 7 days | 10 days | 14 days | 21 days | 28 days |
| Air curing(PEG-4000-0%) | 0 | 53 | 75 | 90 | 106 | 133 | 143 |
| PEG-4000-0.1% | 0 | 13 | 27 | 33 | 43 | 53 | 63 |
| PEG-4000-0.5% | 0 | 17 | 30 | 43 | 55 | 66 | 76 |
| PEG-4000-1% | 0 | 11 | 22 | 30 | 43 | 50 | 60 |

- It is also been observed that in case of specimens with self curing agent of PEG 4000-1% dosage the weight loss is less when compared to other dosages ( 0.1%, 0.5%) of self curing agent.

Table.5 Average weight losses of PEG 4000

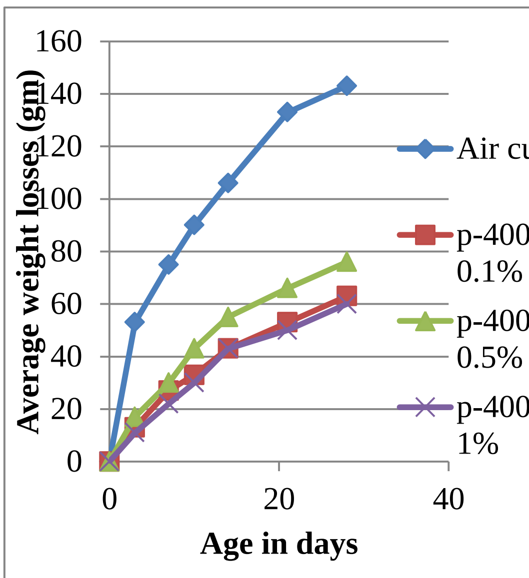


Figure.3 Variation of average weight losses with age

b) Water Retention Test Results of PEG 200:

Concrete with low molecular weight polyethylene glycol subjected to indoor curing was studied by weighing the samples at regular intervals of 3 days, with digital weighing of accuracy 5 gm up to 28 days. The results were recorded in Table 6. The plot of weight loss and average weight loss with different percentage of polyethylene glycol is shown in Figure 4. The following are the observations of water retentivity of concrete.

- it is clearly observed that the specimen without self curing agent i.e., in air curing losing more weight when compared to specimens with dosage of 0.1%, 0.5%, 1% of self curing agent.
- It is also been observed that in case of specimens with self curing agent of PEG 200-1% dosage the weight loss is more when compared to other dosages ( 0.1%, 0.5%) of self curing agent.
- It is also been observed that in case of specimens with self curing agent of PEG 4000-0.1% dosage the weight loss is less when compared to other dosages ( 0.5%, 1%) of self curing agent.

| ...RAGE WEIGHT LOSS OF CUBES AT DIFFERENT ...S (gms) | | | | | | | |
|---|---|---|---|---|---|---|---|
| ...enclature of mix | 0 days | 3 days | 7 days | 10 days | 14 days | 21 days | 28 days |
| Air curing | 0 | 53 | 75 | 90 | 106 | 133 | 143 |
| PEG-200-0.1% | 0 | 13 | 26 | 35 | 46 | 56 | 66 |
| PEG-200-0.5% | 0 | 16 | 28 | 41 | 55 | 70 | 80 |
| PEG-200-1% | 0 | 45 | 56 | 58 | 66 | 83 | 93 |

Table .6 Average weight losses of PEG 200

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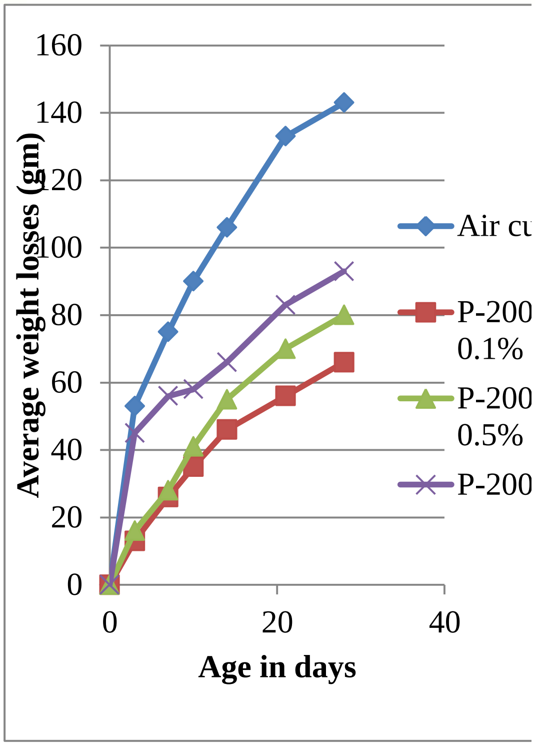


Figure .4 Variation of average weight losses with age

C. Compressive Strength Test Results

a). Compressive strength result of PEG 4000

As per the Table 7 and Figure 5 the following are the observations on compressive strength for indoor curing and wet curing.

- The compressive strength of water curing without self curing agent is more when compared to other dosages (air curing, PEG 4000-0.1%, 0.5%, 1% ).
- The compressive strength of PEG 4000-1% dosage of self curing agent is more compared to other dosages of self curing agent (air curing, PEG 4000-0.1%, 0.5% ).
- PEG 4000-1% dosage of self curing agent has shown better strength than air curing (0% of self curing agent ) but not so good as water curing ( 0% of self curing agent ).
- The compressive strength of PEG 4000-0.5% dosage of self curing agent is lesser compared to other dosages (0.1%, 1%).

| Nomenclature of mix | 0 days (N/mm$^2$) | 7 days (N/mm$^2$) | 14 days (N/mm$^2$) | 28 days (N/mm$^2$) |
|---|---|---|---|---|
| Air curing | 0 | 42.22 | 46.96 | 58.51 |
| Water curing | 0 | 57.77 | 64.44 | 78.22 |
| PEG-4000-0.1% | 0 | 47.4 | 52.59 | 70.36 |
| PEG-4000-0.5% | 0 | 46.96 | 51.85 | 67.1 |
| PEG-4000-1% | 0 | 52.59 | 64.44 | 75.25 |

Table.7 Compressive Strength Test Results of PEG 4000

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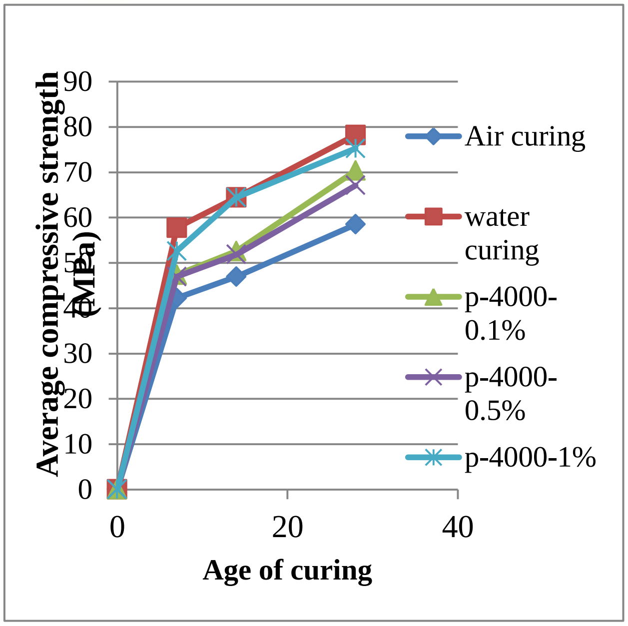


Figure.5 Variation of average compressive strength with age

Figure.6 Tested Specimens of PEG 4000

b). Compressive strength result of PEG 200

As per the Table 8 and Figure 7 the following are the observations on compressive strength for indoor curing and wet curing.

- The compressive strength of water curing without self curing agent is more when compared to other dosages (air curing, PEG 200-0.1%, 0.5%, 1%).
- The compressive strength of PEG 200-0.1% dosage of self curing agent is more compared to other dosages of self curing agent (air curing, PEG 4000-0.5%, 1%).
- PEG 200-0.1% dosage of self curing agent has shown better strength than air curing (0% of self curing agent) but not so good as water curing ( 0% of self curing agent ).
- The compressive strength of PEG 200-1% dosage of self curing agent is lesser compared to other dosages (0.1%, 0.5%).

| Nomenclature of mix | 0 days (N/mm$^2$) | 7 days (N/mm$^2$) | 14 days (N/mm$^2$) | 28 days (N/mm$^2$) |
|---|---|---|---|---|
| Air curing | 0 | 42.22 | 46.96 | 58.51 |
| water curing | 0 | 57.77 | 64.44 | 78.22 |
| PEG-200-0.1% | 0 | 56.29 | 60 | 71.11 |
| PEG-200-0.5% | 0 | 50.37 | 59.25 | 65.92 |
| PEG-200-1% | 0 | 47.4 | 55.5 | 64.44 |

Table 8. Compressive Strength Test Results of PEG 200

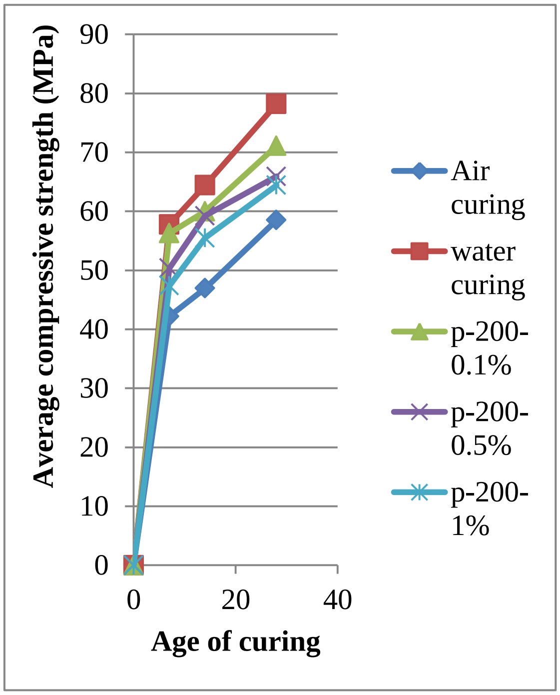


Figure 7. Variation of average compressive strength with age

D. Flexural Strength Test

As per Table 9 & Fig 8 the flexural strength test results for indoor cueing and wet curing are listed below.

- The flexural strength was conducted after fixation of dosage of PEG 4000 and PEG 200.
- For PEG 4000 the optimum dosage is 1%. At 1% of PEG 4000 the flexural strength is more compared to PEG 200.
- For PEG 200 the optimum dosage is 0.1%. at 0.1% of PEG 200 the flexural strength is less compared to PEG 4000.
- But flexural strength value for wet curing (0% of self-curing agent ) is more compared to other dosages (PEG 4000, PEG 200& indoor curing).
- The flexural strength test value for indoor curing is less when compared to other dosages.

| Nomenclature of mix | 7 days ($N/mm^2$) | 14 days ($N/mm^2$) | 28 days ($N/mm^2$) |
|---|---|---|---|
| Air curing | 4.5 | 4.9 | 5.2 |
| Water curing | 5.2 | 5.6 | 6.1 |
| PEG-4000-1% | 5 | 5.5 | 6 |
| PEG-200-0.1% | 5.2 | 5.4 | 5.9 |

Table 9. Average flexural Strength Test Values

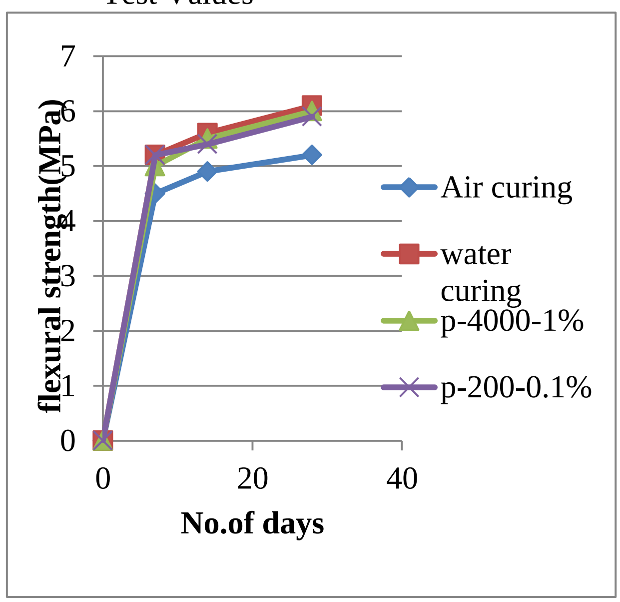


Figure.8 Variation of flexural strength with age

E. Durability Properties of Concrete

Acid Test: In acid test the effect of 5% HCL acid was studied. The various observations made are explained below.

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Acid Attack Factor Test:

In the first stage of the test the change in the physical state of the specimen after 3, 7, 10, 14, 21, 28 days of immersion was observed. For the specimens immersed in 5% HCL, voids were observed on the surface and edges were lost after 28 days. There was a general loss in the physical state of the specimen. The acid attack factor (AAF) of the specimen was determined on the average of four dimensions of cube diagonals. These values are plotted against the number of immersion days in acid.

a) Acid Attack Factor of PEG 400

Table 10and Figure 9 shows the details of Acid Attacking Factor (AAF) Vs Age of curing with self curing compound PEG 4000 specimens respectively.

- In AAF it was observed that lowest AAF value obtained at water curing (0% of self curing compound) when compared to other dosages.
- The lowest value of AAF obtained at indoor curing (0% of self curing compound) when compared to other dosages.
- The AAF of PEG 4000-1% dosage of self curing compound is less compared to other dosages of self curing compound.
- PEG 4000-1% dosage of self curing compound has shown better strength than air curing (0% of self curing compound) but not so good as water curing( 0% of self curing compound).

| Nomenclature of mix | Number of days | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 days | 3 days | 7 days | 10 days | 14 days | 21 days | 28 days |
| Air curing | 0 | 0 | 5.8 | 8.87 | 10 | 16 | 20 |
| Water curing | 0 | 0 | 3.7 | 5 | 6.87 | 8 | 10 |
| PEG-4000-0.1% | 0 | 0 | 4.2 | 5.62 | 7.5 | 11 | 14.5 |
| PEG-4000-0.5% | 0 | 0 | 5 | 6.37 | 8.12 | 12.7 | 16.5 |
| PEG-4000-1% | 0 | 0 | 4 | 5.5 | 7.12 | 8.5 | 11 |

Table 10. Average Acid Attacking Factor values of PEG 4000 when immersed in 5% HCL

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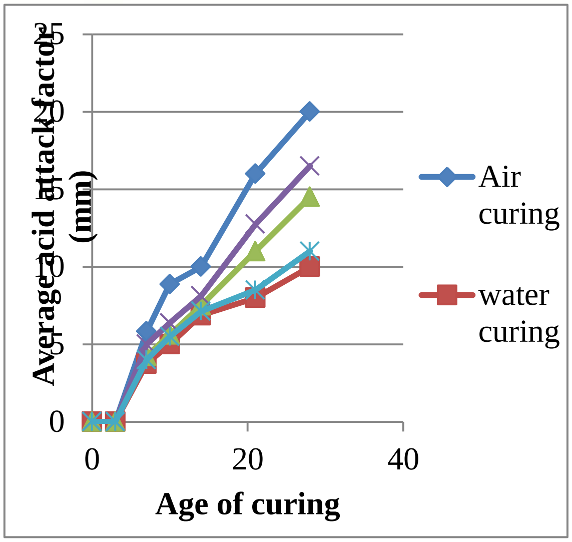


Figure 9: Variation of average AAF with age

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Figure 10. Measuring diagonal dimension of cube

b) Acid Attack Factor of PEG 200

Table 11 and Figure 11: shows the details of Acid Attacking Factor (AAF) Vs Age of curing with self curing compound PEG 200 specimens respectively.

- In AAF it was observed that lowest AAF value obtained at water curing ( 0% of self curing compound) when compared to other dosages.
- The lowest value of AAF obtained at indoor curing (0% of self curing compound) when compared to other dosages.
- The AAF of PEG 200-0.1% dosage of self curing compound is less compared to other dosages of self curing compound.
- PEG 200-0.1% dosage of self curing compound has shown better strength than air curing (0% of self curing compound) but not so good as water curing(0% of self curing compound).

| Nomenclature of mix | Number of days | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 days | 3 days | 7 days | 10 days | 14 days | 21 days | 28 days |
| Air curing | 0 | 0 | 5.8 | 8.87 | 10 | 16 | 20 |
| Water curing | 0 | 0 | 3.7 | 5 | 6.87 | 8 | 10 |
| PEG-200-0.1% | 0 | 0 | 4.1 | 5.62 | 7.25 | 9.25 | 12.2 |
| PEG-200-0.5% | 0 | 0 | 5.1 | 6.62 | 8.37 | 14.5 | 18.2 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PEG-200-1% | 0 | 0 | 5.3 | 7.25 | 8.62 | 15 | 19.5 |

Table 11. Avg Acid Attacking Factor values of PEG 200 when immersed in 5% HCL

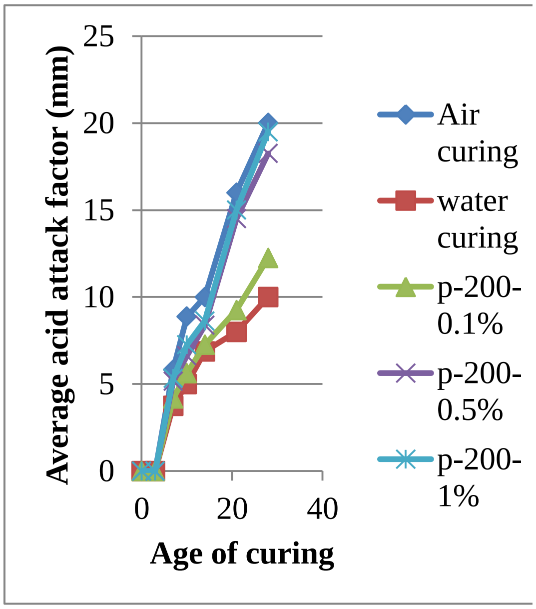


Figure 11: Variation of average AAF with age

Acid durability factor:
a) ADF of PEG 4000
The acid durability factor (ADF) of the specimens was calculated and plotted against the dosage of curing compound as shown in the following Table 12, Figure 12& Figure 13.

| Nomenclature of mix | AVERAGE ACID DURABILITY FACTOR VALUES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7 days | | | 14 days | | | 28 days | | |
| | % loss of strength | $S_r$(%) | ADF | % loss of strength | $S_r$(%) | ADF | % loss of strength | $S_r$(%) | ADF |
| Air curing | 23.497 | 76.503 | 19.12 | 34.89 | 65.1 | 32.55 | 41.4 | 58.59 | 58.59 |
| Water curing | 9.9 | 90.09 | 22.52 | 14.77 | 85.22 | 42.61 | 18.42 | 81.57 | 81.57 |
| PEG-4000-0.1% | 13.37 | 86.62 | 21.65 | 18.78 | 81.21 | 40.6 | 26.9 | 73.09 | 73.09 |
| PEG-4000-0.5% | 14.83 | 85.16 | 21.29 | 19.09 | 80.9 | 40.45 | 27.61 | 72.38 | 72.38 |
| PEG-4000-1% | 10.14 | 89.85 | 22.46 | 13.93 | 86.06 | 43.03 | 19 | 80.99 | 80.99 |

Table 12 .Acid Durability Factor values of PEG 4000 for 5% HCL

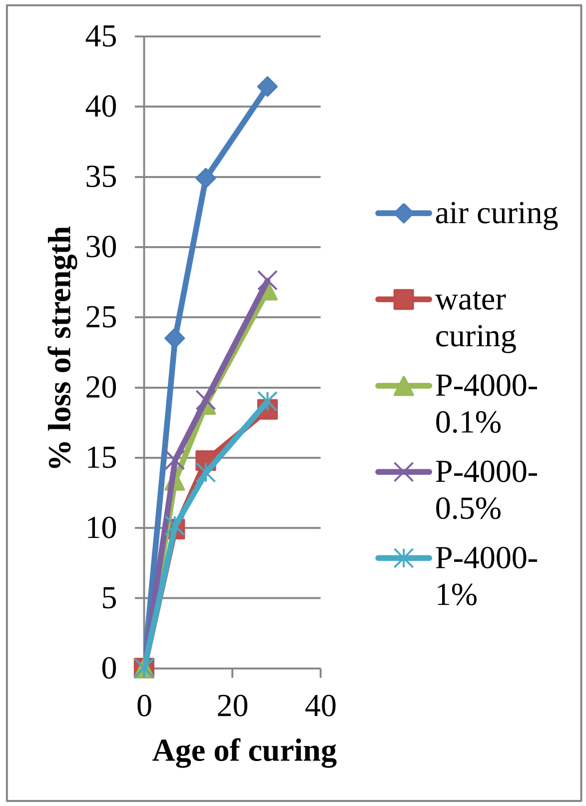


Figure 12. Variation of % loss of strength with age

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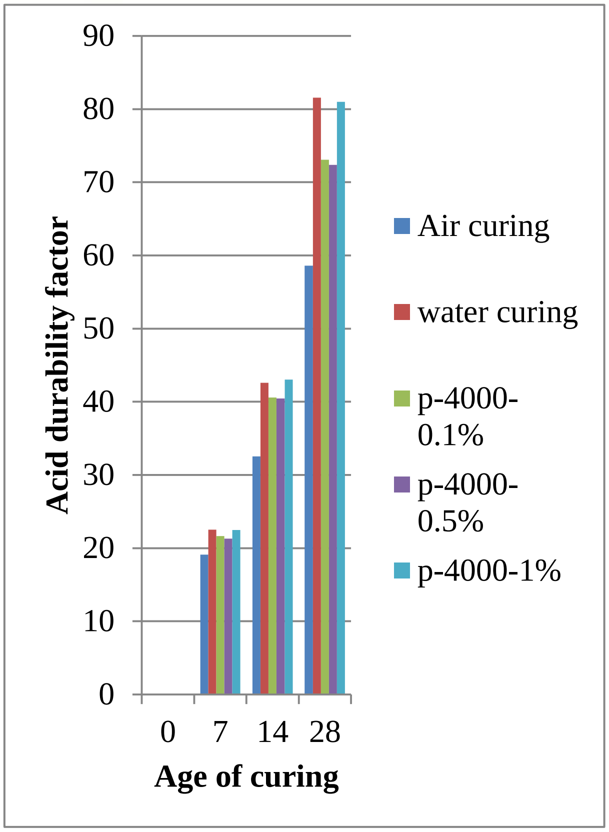


Figure 13: Variation of ADF with age

Figure 14. Visual observation of cube removing from 5% HCL

b). ADF of PEG 200

The acid durability factor (ADF) of the specimens was calculated and plotted against the dosage of curing compound as shown in the following Table 13& Figure 15, 16.

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Table 13. Acid Durability Factor values of PEG 200 for 5% HCL

| Nomenclature of mix | AVERAGE ACID DURABILITY FACTOR VALUES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7 days | | | 14 days | | | 28 days | | |
| | % loss of strength | Sr (%) | ADF | % loss of strength | Sr (%) | ADF | % loss of strength | Sr (%) | ADF |
| Air curing | 23.497 | 76.50 | 19.12 | 34.89 | 65.1 | 32.55 | 41.4 | 58.59 | 58.59 |
| Water curing | 9.9 | 90.09 | 22.52 | 14.77 | 85.22 | 42.61 | 18.42 | 81.57 | 81.57 |
| PEG-200-0.1% | 8.92 | 91.07 | 22.76 | 14.28 | 85.71 | 42.85 | 19.64 | 80.35 | 80.35 |
| PEG-200-0.5% | 16.2 | 83.79 | 20.94 | 23.42 | 76.57 | 38.28 | 29.2 | 70.79 | 70.79 |
| PEG-200-1% | 20.19 | 79.8 | 19.95 | 26.1 | 73.86 | 36.94 | 33.49 | 66.5 | 66.5 |

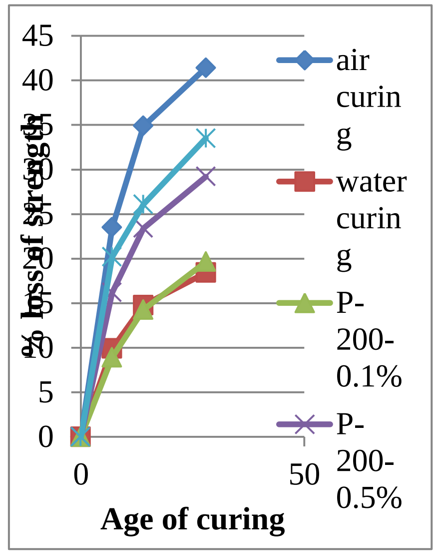


Figure 15. Variation of % loss of strength with age

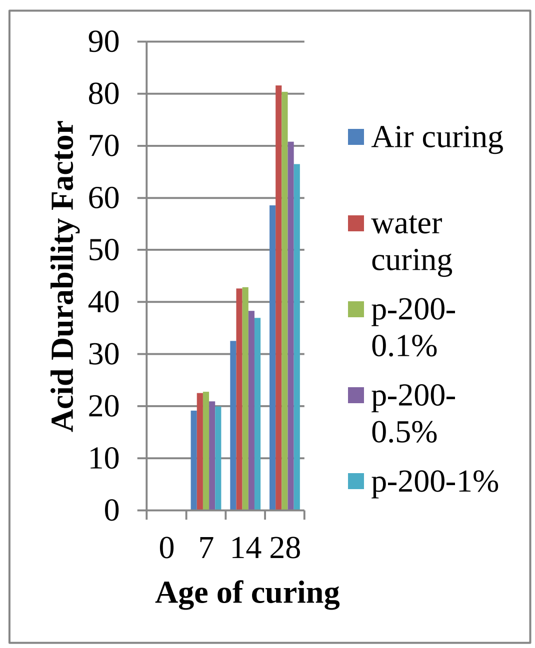


Figure 16.: Variation of ADF with age

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## 6. CONCLUSION

After the analysis of the result of the experimental programme the following conclusions were arrived.

a. High grade concrete containing Ordinary Portland Cement with Polyethylene Glycol in indoor curing with 0% dosage (by weight of cement) has maximum weight loss when compared to the 0.1%, 0.5%, 1% dosages.

b. High grade concrete containing Ordinary Portland Cement with Polyethylene Glycol (PEG 4000) in indoor curing with 1% dosage (by weight of cement) has minimum weight loss when compared to the 0%, 0.1%, 0.5% dosages of PEG 4000.

c. High grade concrete containing Ordinary Portland Cement with Polyethylene Glycol (PEG 200) in indoor curing with 0.1% dosage (by weight of cement) has minimum weight loss when compared to the 0%, 0.5%, 1% dosages of PEG 200.

d. In this investigation, it is noticed that High grade concrete containing Ordinary Portland Cement with 1% dosage (by cement weight) of PEG 4000 gives better results when compared to the 0.1% dosage of PEG 200.

e. Compressive strength of High grade concrete with 0% dosage of Polyethylene Glycol in wet curing is higher compared to the 0% dosage in indoor curing.

f. Compressive strength of High grade concrete with 1% dosage of PEG 4000 in indoor curing is higher when compared to the 0%, 0.1%, 0.5%.

g. Compressive strength of High grade concrete with 0.1% dosage of PEG 200 in indoor curing is higher when compared to the 0%, 0.5%, 1%.

h. In this investigation, it is noticed that High grade concrete containing Ordinary Portland Cement with 1% dosage (by cement weight) of PEG 4000 gives better results when compared to the 0.1% dosage of PEG 200.

i. In case of Acid attack test of High grade concrete with 1% dosage of PEG 4000 in indoor curing gives the better results compared to other dosages.

j. In case of Acid attack test of High grade concrete with 0.1% dosage of PEG 200 in indoor curing gives the better results compared to other dosages.

k. In this investigation, it is noticed that High grade concrete containing Ordinary Portland Cement with 1% dosage (by cement weight) of PEG 4000 gives better results when compared to the 0.1% dosage of PEG 200.

l. In case of Acid durability factor test of High grade concrete with 1% dosage of PEG 4000 in indoor curing gives the better results compared to other dosages.

m. In case of Acid durability factor test of High grade concrete with 0.1% dosage of PEG 200 in indoor curing gives the better results compared to other dosages.

n. In this investigation, it is noticed that High grade concrete containing Ordinary Portland Cement with 1% dosage (by cement weight) of PEG 4000 gives better results when compared to the 0.1% dosage of PEG 200.

o. In this investigation, it is noticed that High grade concrete containing Ordinary Portland Cement with 1% dosage (by cement weight) of PEG 4000 gives better results when compared to the 0.1% dosage of PEG 200.

p. In general it was concluded from the investigation that specimens with higher strength were also exhibiting superior performance from Acid Attack point of view.

## 7. FUTURE WORK

In the present study the has been done with the usage of chemical admixture like BASF Glenium B233 type super plasticizer and self curing compounds like polyethylene glycol(PEG) with molecular weights 4000 and 200. In future work we have to use different types of self curing compounds like polyether, liquid paraffin wax etc...and mineral admixtures like fly ash, GGBS.

## 8. REFERENCES

a. M.V. JaganadhaKumar, M. Srikanth, Dr.K. Jaganadha Rao “Strength Characteristics of Self-curing Concrete” IJERT | Sep 2012.
b. Sathanandham.T1,Gobinath.R2,Naveen Prabhu.M3,Gnanasundar.S3,Vajravel.K 3,Sabariraja.G3, Manoj kumar.R3, Jagathishprabu.R3 “ Preliminary Studies of Self curing Concrete With the addition of Polyethylene glycol” IJERT, Vol. 2 Issue 11, November – 2013 ISSN: 2278-0181.
c. Prof.VinayakVijapur, Manjunath .G. Tontanal“ An Experimental Investigation on Behaviour of Self Cured Steel Fibre Reinforced Concrete″ International Journal of Emerging Trends in Engineering and Development, Issue 3, Vol.5 (September 2013) , ISSN 2249-6149.
d. Amal Francis k#1, Jino John#2 “ Experimental Investigation on Mechanical Properties of Self Curing Concrete” International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.2 (March 2013) , ISSN 2249-6149.
e. Amr S. El-Dieb, Tamer A. El-Maaddawy, Ahmed A. M. Mahmud“ Water-Soluble Polymers as Self curing agents in cement mixes”, Advances in Cement Research,2012, Volume 24 Issue 5.
f. RK. Dhir’, P.C. Hewlett** and T.D. Dyer*, “ Durability of Self Cured Concrete ” Cement and Concrete Research, Vol. 25. No. 6, pp. 1153-1158.1995.
g. SemionZhutovsky, Konstantin Kovler “Effect of internal curing on durability-related properties of high performance concrete” Cement and Concrete Research 42 (2012) 20–26.

h. C. ChellaGifta*1, S. Prabavathy2 and G. Yuvaraj Kumar2 “Study on Internal Curing of High Performance Concrete Using Super Absorbent Polymers and Light Weight Aggregates″Asian Journal of Civil Engineering (BHRC) , vol. 14, no. 5 (2013).

i. Ryan Henkensiefken.a, , Javier Castro.b, Dale Bentz.c, Tommy Nantung.d, Jason Weiss.b“Water Absorption in Internally Cured Mortar made with Water-filled Lightweight Aggregate ” Cement and Concrete Research 39 (2009) 883–892.

j. Ryan Henkensiefken.a, Dale Bentz.b, Tommy Nantung.c, Jason Weiss a, “Volume Change and Cracking in Internally Cured Mixtures made with Saturated Lightweight Aggregate Under Sealed and Unsealed Conditions,Cement&Concrete Composites 31 (2009) 427–437.

k. Nirav R Kholia, [2]Prof. Binita A Vyas, [3]Prof. T. G. Tank ”Effect on Concrete by Different Curing Method and Efficiency of Curing Compounds – A review ” ,Kholia et al., International Journal of Advanced Engineering Technology, E-ISSN 0976-3945.

l. Pietro Lura, Dale P. Bentz, David A. Lange, Konstantin Kovler and ArnonBentur “Pumice Aggregates for Internal Water Curing”.

m. Patel ManishkumarDahyabhai*,Prof.Jayeshkumar R. Pitroda**“Self-curing Concrete: New Technique for Concrete Curing – A Literature Review ” journal of international academic research for multidisciplinary,Impact Factor 1.393, Volume 1, Issue 9, October 2013.

n. Text book on “Concrete Technology- “Theory and Practice” by M.S.SHETTY.

o. IS-383-1970, “Specification for coarse and fine aggregates from natural sources for concrete”.

p. IS: 516–1956 (Reaffirmed 1999), “Indian Standard Methods of Tests for Strength of Concrete”.

q. IS: 12269:1987, “Specifications for 53 grade ordinary Portland cement”.

r. IS: 2386, “Method of test for aggregate for concrete”, reprinted 1997.