Preliminary Studies Of Self Curing Concrete With The Addition Of Polyethylene Glycol

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ABSTRACT:
Concrete is most widely used construction material due to its good compressive strength and durability. Depending upon the nature of work the cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain concrete. Plain concrete needs congenial atmosphere by providing moisture for a minimum period of 28 days for good hydration and to attain desired strength. The properties of hardened concrete, especially the durability, are greatly influenced by curing since it has a remarkable effect on the hydration of the cement. Any laxity in curing will badly affect the strength and durability of concrete. 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 shrinkage reducing admixture polyethylene glycol (PEG 4000) in concrete which helps in self curing and helps in better hydration and hence strength. In the present study, the affect of admixture (PEG 4000) on compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG by weight of cement from 0% to 2% were studied for M20. It was found that PEG 4000 could help in self curing by giving strength on par with conventional curing. It was also found that 1% of PEG 4000 by weight of cement was optimum for M20 grade concretes for achieving maximum strength without compromising workability.

Keywords: Self curing concrete, hardened property, hydration, curing efficiency

1. 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% [1]. 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

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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. When concrete is cured at high temperature normally develops higher early strength than concrete produced and cured at lower temperature, but strength is generally lowered at 28 days and later stage [3]. A durable concrete is one that performs satisfactorily under the anticipated exposure condition during its designed service life. In addition to the normal concrete mix some additional compounds in proper dosage and materials such as fly ash are used to increase the durability and strength of the concrete mix.

1.1 Methods of self curing:

Currently, there are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate (LWA) in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses poly-ethylene glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention

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1.2 Mechanism of Internal Curing:

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (free energy) between the vapors 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 vapors pressure, thus reducing the rate of evaporation from the surface.

1.2 Significance of 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 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
- Polyethylene glycol

1.4 Advantages of Internal Curing

- ✓ Internal curing (IC) is a method to provide the water to hydrate all the cement, accomplishing what the mixing water alone cannot do.
- ✓ Provides water to keep the relative humidity (RH) high, keeping self-desiccation from occurring.
- ✓ Eliminates largely autogeneous shrinkage.
- ✓ Maintains the strengths of mortar/concrete at the early age (12 to 72 hrs.) above the level where internally & externally induced strains can cause cracking.
- ✓ Can make up for some of the deficiencies of external curing, both human related (critical period when curing is required in the first 12 to 72 hours) and hydration

1.5 Polyethylene Glycol:

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H(OCH2CH2)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.

2. LITERATURE REVIEW:

The properties of hardened concrete, especially the durability, are greatly influenced by curing since it has a remarkable effect on the hydration of the cement. The advancements in the construction and chemical industry have paved way for the development of the new curing techniques and construction chemicals such as Membrane curing compounds, Self-curing agents, Wrapped curing, Accelerators, Water proofing compounds etc. With the growing scale of the project conventional curing methods have proven to be a costly affair as there are many practical issues and they have been replaced by Membrane curing compounds and Self-curing agents up to some extent as they can be used in inaccessible areas, Vertical structures, Water scarce areas etc .It is most practical and widely used curing method. In this review paper effort has been made to understand the working and efficiency of curing methods which are generally adopted in the construction industry and compared with the conventional water curing method. Conventional water curing is the most efficient method of curing as compared to Membrane curing, Self-curing, Wrapped curing and Dry air curing methods. Using Membrane curing and Self-Curing methods one can achieve 90% of efficiency as compared to Conventional Curing method. Self Curing method is most suitable for high-rise buildings especially in columns and inaccessible areas. Membrane curing compounds are most practical and widely used method it is most suitable in water scarce area. Wrapped curing is less efficient than Membrane curing and Self-Curing it can be applied to simple as well as complex shapes. Dry-Air curing should be avoided at the construction sites because designed design strength is not achieved by this method. The average efficiency of the curing compound increases with curing age initially by reduces at later age. Application of the curing compound is significantly dependent on the time of application of the compound. (Nirav R Kholia 2013 et al.)

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Most of the concrete that is produced and placed each year all over the world already does self-cure to some extent. Some of it is not intended to have anything done to its exterior surface, except perhaps surface finishing. Yet the concrete's ability to serve its intended purpose is not significantly reduced.―Curing is the maintaining of a satisfactory moisture content and temperature in concrete during its early stages so that desired properties (of concrete) may develop. Curing is essential in the production of concrete that will have the desired properties. The strength and durability of concrete will be fully developed only if it is cured. No action to this end is required, however, when ambient conditions of moisture, humidity, and temperature are sufficiently favourable to curing. Otherwise, specified curing measures shall start as soon as required. Most of the concrete in the world is placed in quantities that are of sufficient thickness such that most of the material will remain in satisfactory conditions of temperature and moisture during its early stages. Also, there are cases in which concrete has been greatly assisted in moving toward a self-curing status either inadvertently or deliberately through actions taken in the selection and use of materials. To achieve good cure, excessive evaporation of water from a freshly cast concrete surface should be prevented. Failure to do this will lead to the degree of cement hydration being lowered and the concrete developing unsatisfactory properties. Curing can be performed in a number of ways to ensure that an adequate amount of water is available for cement hydration to occur. However, it is not always possible to cure concrete without the need for applying external curing methods. Most paving mixtures contain adequate mixing water to hydrate the cement if the moisture is not allowed to evaporate. It should be possible to develop an oil, polymer, or other compound that would rise to the finished concrete surface and effectively seal the surface against evaporation New developments in curing of concrete are on the horizon as well. In the next century, mechanization of the placement, maintenance, and removal of curing mats and covers will advance as performance-based specifications quantify curing for acceptance and payment. In addition, effective sealants and compounds that prevent the loss of water and promote moist curing conditions will be in high demand. Self-curing concrete should become available in the not-too-distant future. (Tarun R. Naik et al.)

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Proper curing of concrete structures is important to ensure that they meet their intended performance and durability requirements. Curing plays a major role in developing the concrete microstructure and pore structure. Self curing distributes the extra curing water throughout the entire 3-D concrete microstructure so that it is more readily available to maintain saturation of the cement paste during hydration, avoiding self-desiccation and reducing autogenous shrinkage. The scope of the research included characterization of super absorbent polymer for use in self curing. Experimental measurements were performed on to predict the compressive strength, split tensile strength and flexural strength of the concrete containing Super Absorbent Polymer (SAP) at a range of 0%, 0.2%, 0.3%, and 0.4% of cement and compared with that of cured concrete. The grade of concrete selected was M40. Addition of SAP leads to a significant increase of mechanical strength (Compressive and Split tensile) Maximum compressive stress develop in M-40 grade self curing concrete by adding sap 0.3% of cement. Split tensile strength of self curing concrete for dosage of SAP 0.3% of cement was higher than non self curing concrete. Flexural strength of self curing concrete for dosage of SAP 0.3% of cement was higher than non self curing concrete. Performance of the self-curing agent will be affected by the mix proportions mainly the cement content and the w/c ratio. (Amal Francis k, 2013 et al.)

3. SCOPE AND OBJECTIVE:

• The scope of the paper is to study the effect of polyethylene glycol (PEG 400) on strength characteristics of Self-curing concrete

• The objective is to study the mechanical characteristic of concrete i.e., compressive strength by varying the percentage of PEG from 0% to 2% by weight of cement for both M20 grade of concrete.

4. MATERIALS USED:

The different materials used in this investigation are

Cement: Ordinary Portland Cement (OPC-43 grade) conforming to IS: 8112-198986. The specific gravity of cement is 3.15.

Fine aggregate: Locally available river sand conforming to Zone II of IS: 383- 19707 was used as fine aggregate with specific gravity 2.89.

Coarse aggregate: 20mm size crushed granite stone obtained from the local quarry with specific gravity 2.69

Polyethylene Glycol-4000: Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H(OCH2CH2)nOH, where n is the average number of repeating oxyethylenegroups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with anumeric suffix which indicates the average molecular weight. One common feature of PEG appears to be the water-soluble nature.

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4.1 Mix proportions:

The control mix was proportioned by IS 10262 : 20098 to obtain compressive strength of 20 MPa. The identification, mix proportion and quantity of material taken for one meter cube of self curing concrete mixes.The mixeswere obtained by adding PEG 4000 content 0.5%,1%,1.5%, and 2% of weight of cement .Additional water added to the mix depend upon the amount of PEG 4000 added by weight of binder.

4.2 Preparation, casting and testing of specimens:

The 150mm concrete cubes were tested for compressive strength at 7 , 14 and 28 days. All the test specimens were stored at room temperature and were kept for self curing.

S.NO	PEG- % of cement	Cement (kg)	PEG (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (lit)
Mix-1	0.5	350	0.05	950	1119	140
Mix-2	1.0	350	0.10	950	1119	171.5
Mix-3	1.5	350	0.15	950	1119	187.3
Mix-4	2.0	350	0.20	950	1119	203

Table 1: Mix proportions per m3

4.3 Compressive strength test:

The test is carried out on 150x150x150 mm size cubes, as per IS: 516-19599. The test specimens are marked and removed from the moulds and unless required for test within 24 hrs. A 2000 KN capacity Compression Testing Machine (CTM) is used to conduct the test. The specimen is placed between the steel plates of the CTM and load is applied at the rate of 140 Kg/Cm2/min and the failure load in kN is observed from the load indicator of the CTM.

5. Results and discussion:

The results of compressive test for various mixes were presented in table and graph below

Concrete Grade: M20 ratio: 1:1.5:3 Cubes: 6nos PEG (4000): 0.5%

DAYS GRADE	7 DAYS	14 DAYS	28 DAYS
M20	430 KN	520 KN	610 KN
M20	460 KN	560 KN	600 KN
AVG Strength value	19.78 N/mm^2	24 N/mm^2	26.88 N/mm^2

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Table 2: Strength characteristics of self cured concrete with 0.5% PEG

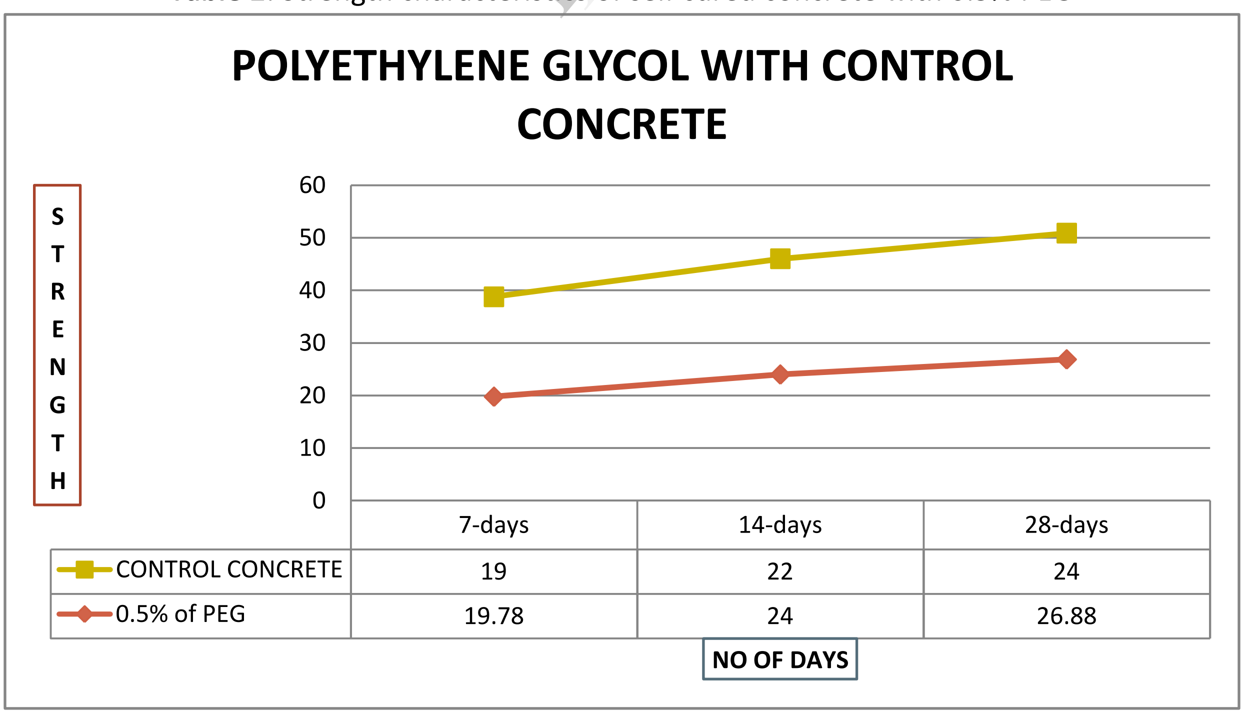

Chart 1: Graph showing 0.5% of polyethylene glycol with control concrete

Concrete Grade: M20 ratio: 1:1.5:3 Cubes: 6nos PEG (4000): 1 %

DAYS GARDE	7 DAYS	14 DAYS	28 DAYS
M20	420 KN	500 KN	590 KN
M20	450 KN	510 KN	570 KN
AVG Strength value	19.33 N/mm^2	22.66 N/mm^2	25.77 N/mm^2

Table 3: Strength characteristics of self cured concrete with 1% PEG

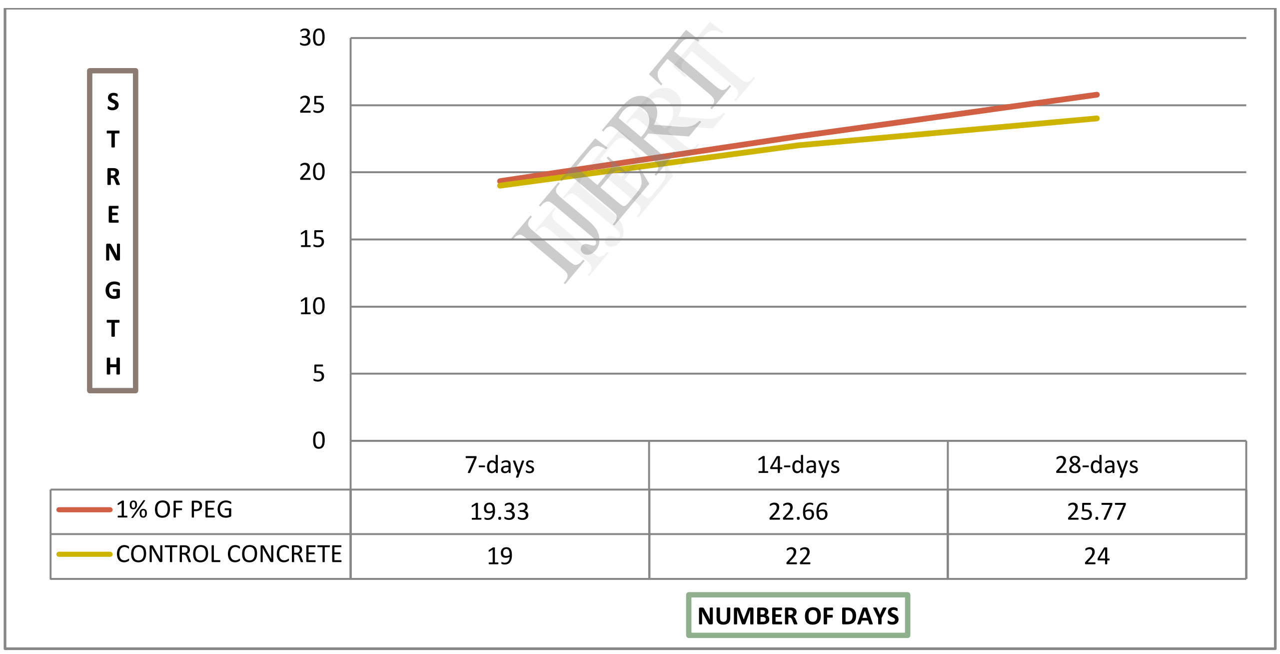

Chart 2: Graph showing 1 % of Polyethylene glycol with control concrete

Concrete Grade: M20 ratio: 1:1.5:3 Cubes: 6nos PEG (4000): 1.5 %

DAYS GARDE	7 DAYS	14 DAYS	28 DAYS
M20	450 KN	540 KN	630 KN
M20	470 KN	560 KN	650 KN
AVG Strength value	20.44 N/mm^2	20.44 N/mm^2	28.44 N/mm^2

Table 4: Strength characteristics of self cured concrete with 1.5% PEG

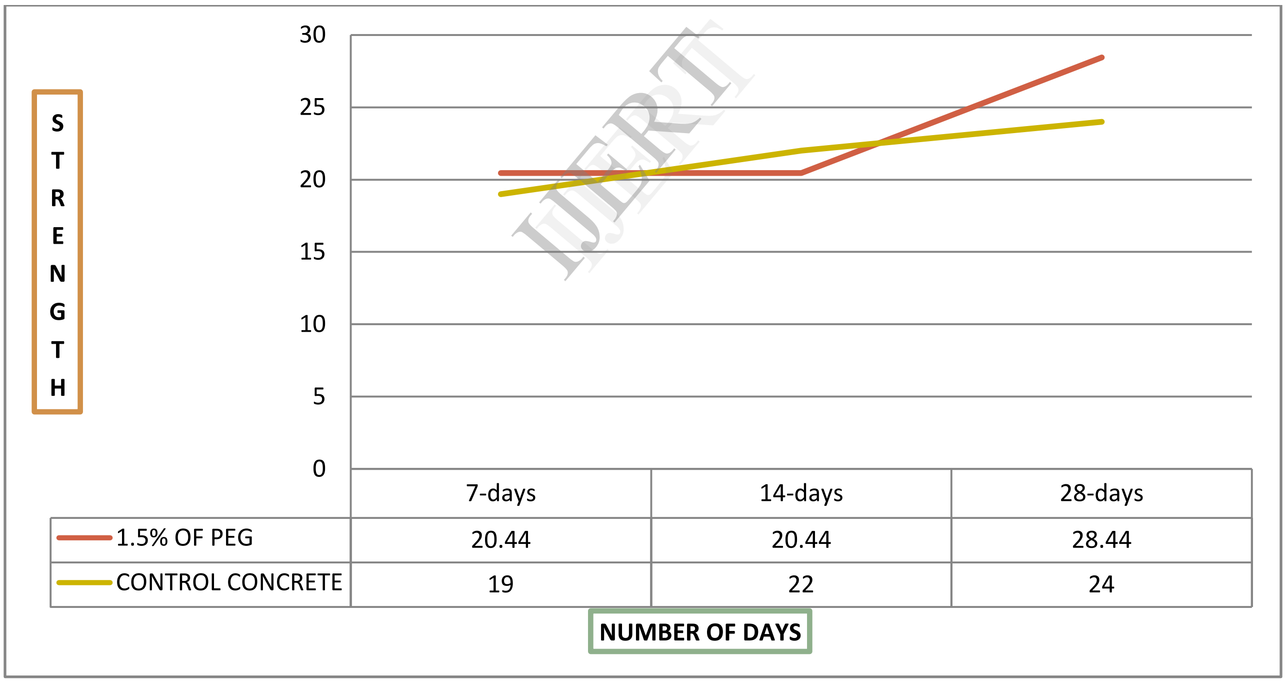

Chart 3: Graph showing 1.5 % of Polyethylene glycol with control concrete

Concrete Grade: M20 ratio: 1:1.5:3 Cubes: 6nos PEG (4000): 2 %

DAYS / GARDE	7 DAYS	14 DAYS	28 DAYS
M20	470 KN	560 KN	640 KN
M20	480 KN	590 KN	680 KN
AVG Strength value	21.11 N/mm^2	25.55 N/mm^2	29.33 N/mm^2

Table 5: Strength characteristics of self cured concrete with 2% PEG

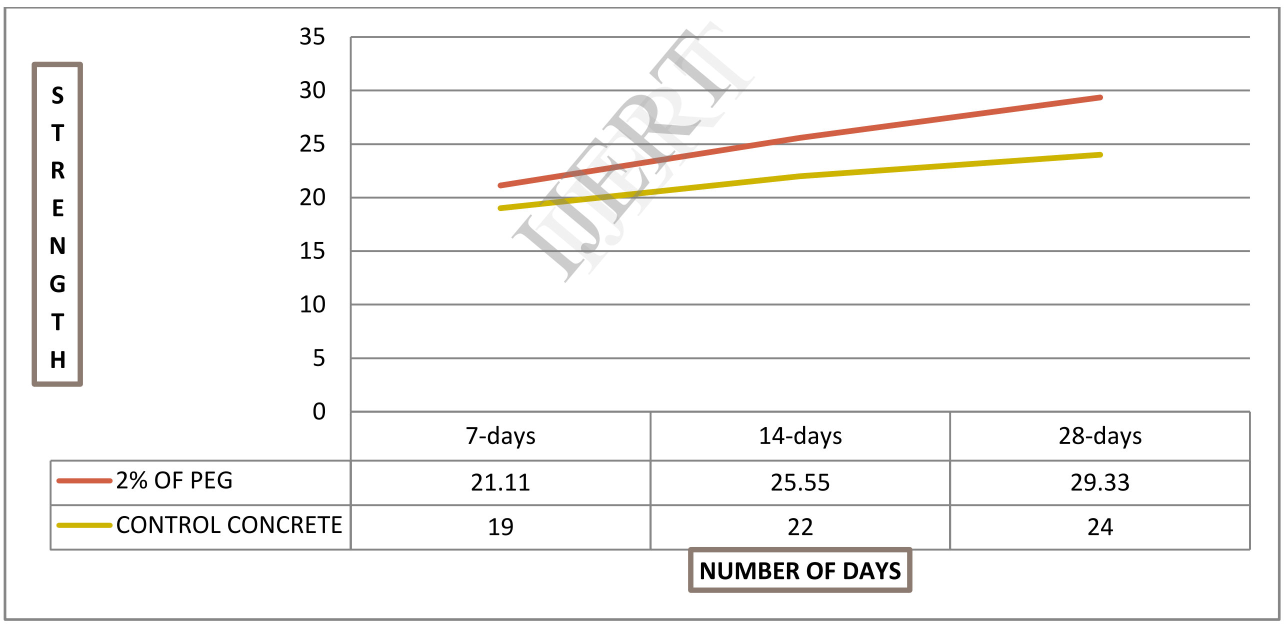

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Chart 4: Graph showing 2 % of Polyethylene glycol with control concrete

The results of the compressive strength are represented in above Tables and the graphical representation. From the table it is noted that Compressive strength is found to increase as the days increases. The compressive strength of normal concrete is achieved in 0.5% PEG, decreases in 1% PEG addition and again abruptly increases in 1.5% and 2% compared to normal concrete.

6. Conclusion:

1. The optimum dosage of PEG4000 for maximum Compressive strength was found to be 1.5% for grades of concrete.
2. As percentage of PEG4000 increased slump increased for M20 grade of concrete.
3. Strength of self curing concrete is on par with conventional concrete.
4. Self curing concrete is the answer to many problems faced due to lack of proper curing.
5. Wrapped curing is less efficient than Membrane curing and Self-Curing it can be applied to simple as well as complex shapes.

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