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SELF-CURING CONCRETE

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ABSTRACT

As water is becoming a scarce material day-by-day, there is an urgent need to do research work pertaining to saving of water in making concrete and in constructions. Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. Curing of concrete plays, a major role in developing the concrete microstructure and pore structure and hence improves its durability and performance.

The use of self-curing admixtures is very important from the point of view that saving of water is a necessity everyday (each 1m3 of concrete requires 3m3 of water in a construction, most of which is used for curing).Keeping importance to this, an attempt has been made to develop self-curing concrete by 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 the conventionally cured concrete.

The use of self-curing agent viz., polyethylene glycol (PEG) of molecular weight400 (PEG-400) for dosages of 0%, 0.5%,1% ,1.5%and 2% by weight of cement added to mixing water in the concrete. Comparative studies were carried out for compressive strength for conventional and self-cured concrete mixture of M30 grade at standard ages (7, 14 and 28days). It was also found that 1% dosage of PEG-400 by weight of cement was optimum for M30 grade of concrete.

1.0 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%.

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, due to DE percolation of the capillary porosity, for example, significant autogenously 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. So, we need a self-curing.

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. 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 is used to increase the durability and strength of the concrete mix.

2.0 SCOPE AND OBJECTIVES OF STUDY:

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 characteristics of concrete such as compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG400 from 0% to 2% by weight of cement for any particular grade.

3.0 LITERATURE REVIEW

- M.V. Jagannathan Kumar, Srikanth, Dr. K. Jagannathan Rao studied that the optimum dosage of PEG400 for maximum strengths (compressive, tensile and modulus of rupture) was found to be 1% for M20 and 0.5% for M40 grades of concrete. As percentage of PEG400 increased slump increased for both M20 and M40 grades of concrete. Strength of self-curing concrete is on par with conventional concrete. Self-curing concrete is the answer to many problems faced due to lack of proper curing.
- Roland Tak Yong Liang, Robert Keith Sun carried work on internal curing composition of concrete which includes a glycol and a wax. The invention provides for the first time an internal curing composition which, when added to concrete or other cementations mixes meets the required standards of curing as per Australian Standard AS 3799.
- Roland Tak Yong Liang, Robert Keith Sun carried work on internal curing composition for concrete which includes glycol and a wax. The invention provides for the first time an internal curing composition which, when added to concrete or other cementations mixes meets the required standards of curing as per Australian Standard AS 3799.
- Wen-Chen Jau stated that self-curing concrete is provided to absorb water from moisture and from air to achieve better hydration of cement in concrete. It reduces the problem when the degree of cement hydration is lowered due to no curing or improper curing by using poly-acrylic acid as a self-curing agent which has strong capability of absorbing moisture from atmosphere and providing water required for curing concrete.
- **Pietro Lura** the main aim of his study was to reach a better conception of autogenous shrinkage in order to be able to model it and possibly reduce it. Once the important role of self-desiccation shrinkage in autogenous shrinkage is shown, the benefits of avoiding self-desiccation through internal curing become apparent.
- **Shikha Tyagi** Studied on self-curing concrete and had use PEG400 as a self-curing agent in concrete. M25 and M40 grade of concrete are adopted for investigation. She added 1-2% of PEG400 by weight of cement for M25 and M40 grade concrete. She was concluded that the optimum dosage of PEG400 for maximum Compressive strength was to be 1% for M25 and 0.5% for M4O grades of concrete.

4.0 EXPERIMENTAL INVESTIGATION

AGGREGATES:

The aggregates have a definite influence on the strength of hardened concrete. Hence, the aggregate used for concrete should be durable, strong, chemically inert and well graded. The aggregates occupy about 75% of the volume of concrete and they greatly influence the properties of concrete. These gives body to the concrete and reduce the shrinkage effect of cement and make the concrete durable.

For adequate consolidation of concrete, the desirable amount of air, water, cement, and fine aggregate (that is, the mortar fraction) should be about 50% to 65% by absolute volume (45% to 60% by mass). Rounded aggregate, such as gravel, requires slightly lower values, while crushed aggregate requires slightly higher values. Fine aggregate content is usually 35% to 45% by mass or volume of the total aggregate content. Aggregates are classified as

- Fine Aggregates
- Coarse Aggregates.

Fine Aggregate:

The other type of aggregates are those particles passing the 9.5 mm (3/8 in.) sieve, almost entirely passing the 4.75 mm (No. 4) sieve, and predominantly retained on the 75 µm (No. 200) sieve are called fine aggregate. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Coarse Aggregate:

Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve and will pass through 3-inch screen, are called Coarse Aggregates coarse aggregate. The coarser the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements.

CEMENT:

Cement is a material with adhesive and cohesive properties. Cement when mixed with mineral fragments and water, binds the particles into a whole compact. Cement is the most important and costliest ingredient of concrete. For the purpose of constructions works, the cement is used to bind stones, sand, bricks, etc.

Mineral	**Chemical formula**	**Oxide composition**	**Abbreviation**
Tri calcium silicate (alite)	Ca3SiO5	$3CaO.SiO_2$	C3S
Di calcium silicate (belite)	Ca2SiO4	$2CaO.SiO_2$	C2S
Tri calcium aluminate	Ca3Al2O4	$3CaO.Al_2O_3$	C3A
Tetra calcium alumina ferrite	Ca4AlnFe2-nO7	4CaO.AlnFe2-nO3	C4AF

CHEMICAL FORMULAE AND CEMENT NOMENCLATURE FOR MAJOR CONSTITUENTS OF PORTLAND CEMENT

ADMIXTURE (POLYETHYLENE GLYCOL)

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H(OCH2CH2)n OH, where n is the average number of repeating oxy ethylene 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 nontoxic, odourless, neutral, lubricating, non-volatile and non-irritating and is used in a variety of pharmaceuticals.

It was found that polyethylene glycol (PEG) of lower molecular weight i.e., PEG 400 is more efficient as a self-curing agent when compared to the PEG of higher molecular weight. Increasing the molecular weight of polyethylene glycol also results in decreasing solubility in water and also past literature reported that hygroscopic capacity decreases as molecular weight increases

MIX DESIGN

Mix calculations:

The M40 mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m^3

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a) Volume of cement $= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$= \frac{397}{3.110} \times \frac{1}{1000}$ $= 0.127\ m^3$

b) Volume of water

$= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$

$= \frac{159}{1} \times \frac{1}{1000}$ $= 0.159\ m^3$

d) Volume of admixture = Depending on mixing percentage PEG 400

e) Volume of all in aggregate = [a – (b + c + d)]

= 1-(0.127+0.159)

= 0.714m3

f) Mass of coarse aggregate = e × Volume of CA × Specific gravity of CA x 1000

= 0.714× 0.66 × 2.68 × 1000

= 1262 kg

g) Mass of fine aggregate = e × Volume of FA× Specific gravity of FA × 1000

= 0.714 × 0.34 × 2.67 × 1000

= 648.16kg

Mix proportions for trail:

Cement = 397.5 kg/ m^3
Water = 159litre
Fine aggregate = 648kg
Coarse aggregate = 1262kg
Water Cement ratio = 0.4

CEMENT	FINE AGGREGATE	COARSE AGGREGATE	W/C RATIO
400	1.62	3.15	0.4

5.0 RESULTS AND DISCUSSIONS

TEST RESULTS ON CEMENT

Fineness of cement	2.88
Standard/Normal Consistency of cement	27 %
Specific Gravity of cement	3.11
Initial setting time (min)	50 min
Final setting time (min)	290 min

TESTS RESULTS ON FINE AGGREGATES:

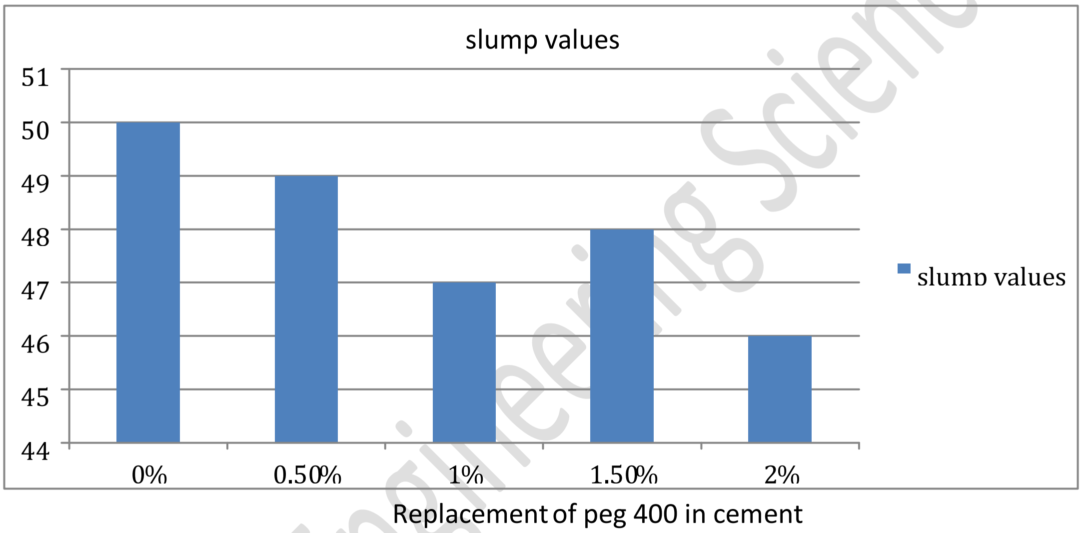
Fineness Modulus	2.66 %
Grading Zone	Zone II 6.2.2
Specific gravity	2.673
Water Absorption (%)	2.8 %
% of bulking of sand	2.23%

TESTS ON COARSE AGGREGATES

Specific gravity	**2.67**
Water Absorption (%)	**1.73**

SLUMP CONE TEST

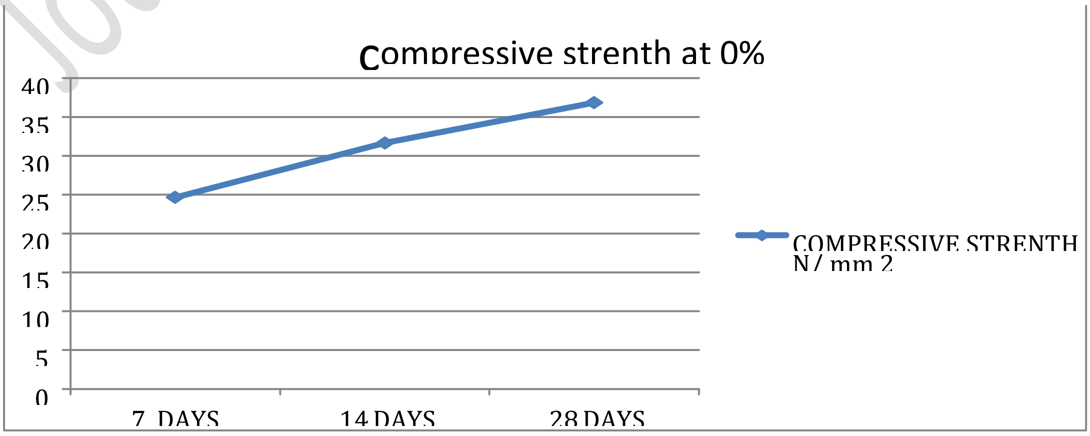
Sl. No	Materials	Slump height (mm)
1	Normal concrete	50
2	Concrete with 0.5% Replacement of PEG	49
3	Concrete with 1% Replacement of PEG	47
4	Concrete with 1.5% Replacement of PEG	48
5	Concrete with 2% Replacement of PEG	46



COMPRESSION STRENGTH TEST

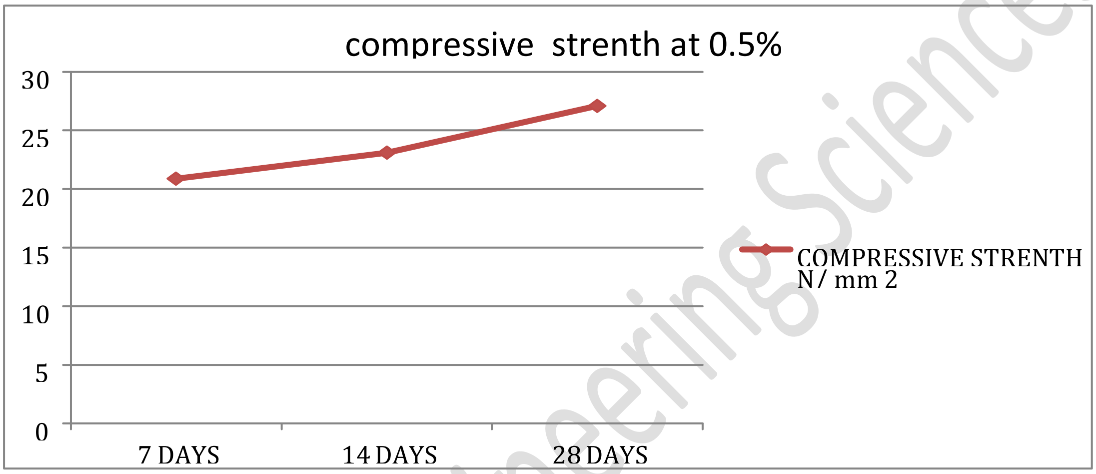
Concrete with 0% of PEG[Cubes]:

Time Of Self Curing	Load Cube-1(KN)	Load Cube-2(KN)	Avg compression Strength [N/mm2]
7 Days	525	575	24.65
14 Days	690	720	31.66
28 Days	830	850	36.85



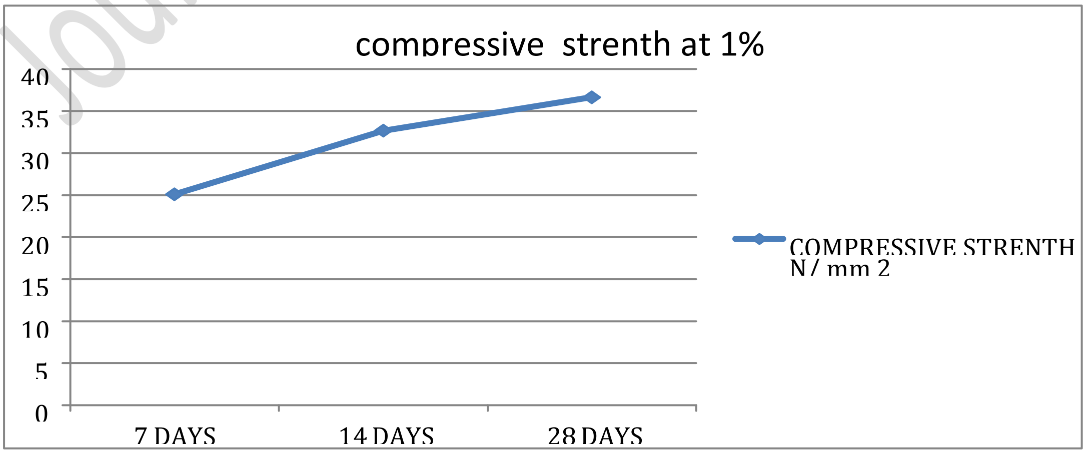
Concrete with 0.5% of PEG[Cubes]:

Time Of Self Curing	Load Cube-1(KN)	Load Cube-2(KN)	Avg compression Strength [N/mm2]
7 Days	440	490	20.88
14 Days	490	550	23.11
28 Days	590	660	27.11



Concrete with 1% of PEG [Cubes]:

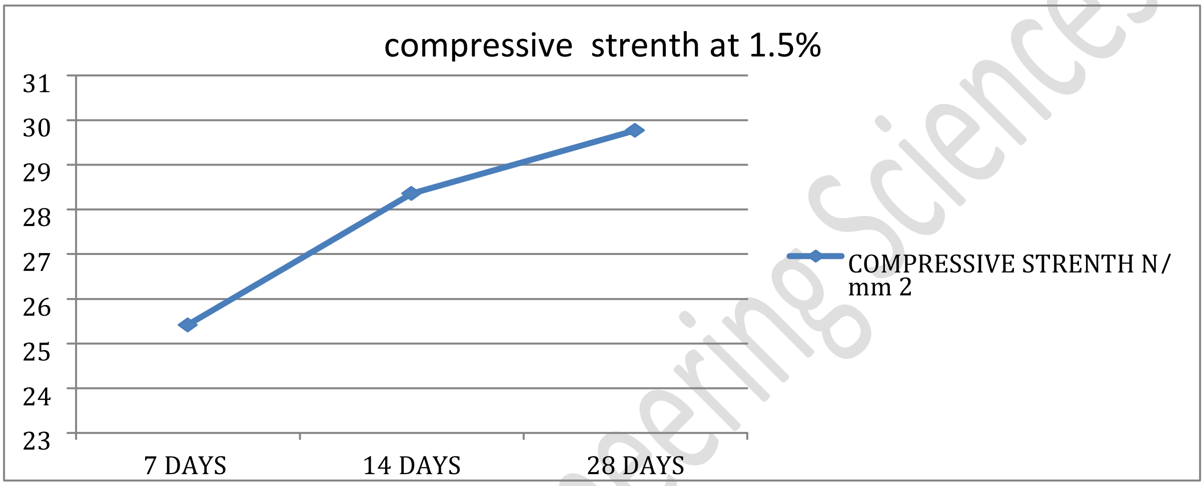
Time Of Self Curing	Load Cube-1(KN)	Load Cube-2(KN)	Avg compression Strength [N/mm2]
7 Days	540	590	25.11
14 Days	720	750	32.66
28 Days	820	830	36.66



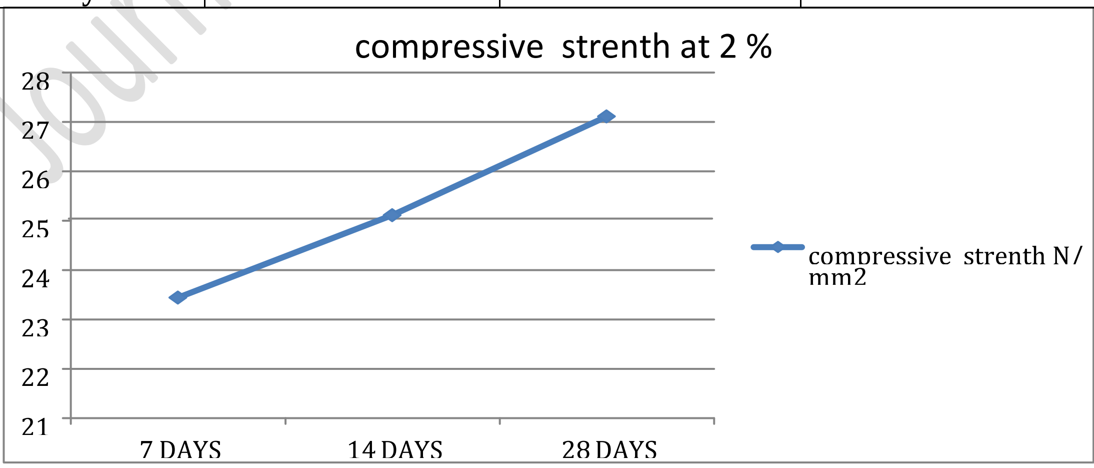
Concrete With 1.5% of PEG [Cubes]

Time of Self Curing	Load Cube-1(KN)	Load Cube-2(KN)	Avg compression Strength [N/mm2]
7 Days	565	585	25.42
14 Days	630	650	28.36
28 Days	660	680	29.77

Concrete With 2% of PEG [Cubes]

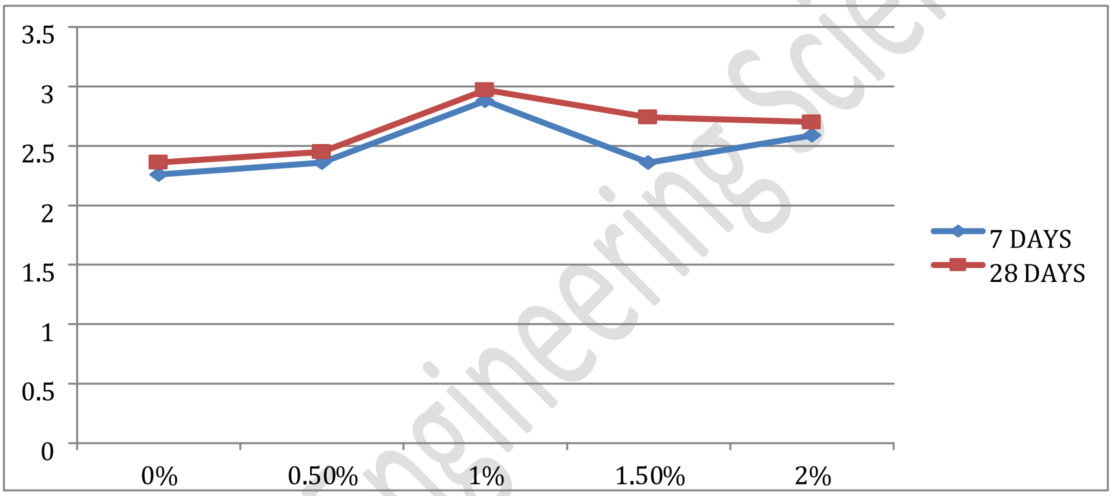


Time of Self Curing	Load Cube-1(KN)	Load Cube-2(KN)	Avg compression Strength [N/mm2]
7 Days	490	520	23.44
14 Days	550	580	25.11
28 Days	600	620	27.11



TESTS ON CYLINDERS

Adding of PEG-400 in percentage weight of cement	Compressive Strength [N/mm2] at 7 days	Compressive Strength [N/mm2] at 28 days
0%	2.26	2.36
0.5%	2.36	2.45
1%	2.36	2.74
1.5%	2.88	2.97
2%	2.59	2.97



5.0CONCLUSION

- The optimum dosage of PEG400 for maximum strengths (compressive, tensile) was found to be 1% for the M30.
- Compared to compressive strength of 0.5%, 1.0% and 1.5% adding admixture of cement by PEG-400, the compressive strength of 2.0% PEG-400 concrete has been decreased.
- Whereas comparing to traditional concrete, compressive strength of concrete has been increased by adding 1% of cement by PEG-400.
- Hence for economical view 2.0% adding admixture is preferable and in the perspective of compressive strength 1% adding is suggested.
- The gain in compressive strength is improved depending upon the adding admixture level of PEG-400 in weight of cement.

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