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A Brief Study on an Effect of Polyethylene Glycol (PEG-400) On Self Curing Concrete

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ABSTRACT: Today 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 concrete.

Concrete needs congenial atmosphere by providing moisture for a minimum period of 28 days for good hydration and to attain desired strength. 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. So many studies are done about the usage of Self curing concrete. In the present study, the affect of admixture Poly Ethylene Glycol-400 (PEG-400) on compressive strength, split tensile strength at different percentage for M25 and M35 mix was studied and it compared And known that what percentage it will get higher strength and also we study that effect of Acid and water absorption on self curing of concrete. The present study was shown about a clear cooperate picture about the strengths of PEG-400 and its stress strain behavior also shown clearly.

KEYWORDS: Self-curing concrete , PEG-400.

I. INTRODUCTION

Cement concrete is an artificial building material that is obtained by mixing together cement, water and some other inert materials. The mixture in a plastic condition when allowed to set becomes as hard as stone. By suitably adjusting the proportions of various ingredients, concrete with sufficient compressive strength for various uses can be developed. The strength of concrete depends mainly on its ingredients, their relative quantities and the manner in which they are mixed and placed.

The term “curing” describes the frequently process by which hydraulic used-cement to concrete matures and develops hardened properties over time as a result of the continued hydration of the cement in the presence of sufficient water and heat. 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 may not possess the desirable strength and impermeability. The near surface region of concrete is particularly 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 mix 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.

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The ACI-308 Code states that “internal by which the hydration curing of cement occurs because of the availability of additional internal water that is not part of the mixing Water.” Conventionally, curing concrete not lost from the surface i.e., curing is taken to happen „from the contrast, „internal curing” is allowing for internal reservoirs (in the form of saturated lightweight fine aggregates, superabsorbent polymers, or saturated wood fibers) Created. “Internal curing”.

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. 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. Curing of concrete plays a major role in developing the concrete microstructure and pore structure and hence improves its durability and performance.

II. LITERATURE REVIEW

Wen-Chen Jau stated that self-curing concrete is provided to absorb water from moisture from air 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. The self-curing agent used in this study was poly acrylic acid (PAA) and polyvalent alcohol. These two chemicals are most hydrophilic in nature. The dosage of self-curing agent was 1% and 2% by weight of cement. Compressive strength and water retentivity test was carried under different relative humidity conditions like 50%, 67.5% and 85%.

The invention is based on the observation that a combination of wax and a glycol, when added to concrete, enables internal curing of concrete which in many respects, is equal to or superior to traditional forms of curing concrete, as assessed by a number of relevant parameters. The invention provides for the first time an internal curing composition which, when added to concrete or other cementitious mixes, meets the required standards of curing (Australian Standard AS 3799).

Many tests have conducted on ordinary concrete viz. rate of evaporation, compressive test, porosity, water absorption at different curing period and also at different proportions of PEG and wax.

A.S. El-Dieb investigated water retention of concrete using water-soluble polymeric glycol as self-curing agent. Concrete weight loss and internal relative humidity measurements with time were carried out, in order to evaluate the water retention of self-curing concrete. Water transport through concrete is evaluated by measuring absorption percentage, permeable voids percentage, water sorptivity and water permeability. The water transport through self-curing concrete is evaluated with age. The effect of the concrete mix proportions on the performance of self-curing concrete were investigated, such as, cement content and water/cement ratio. In this study water retention and hydration of concrete containing self-curing agents is investigated and compared to conventional concrete. Also, water transport through this concrete is evaluated and compared to conventional concrete continuously moist-cured and air-cured. The dosage of self-curing agent was 0.02% by weight of cement. The dosage was kept constant for all the self-curing concrete mixes. The investigation aimed at studying on concrete with different quantities of cement (350-450 kg/m³) at different water- cement ratios (0.3-0.4) both for self, conventional and air- curing concrete and compare the results for different test.

III. DESIGN METHODOLOGY

Mix design by method for M-25 Grade Concrete:

A. Design Stipulations:

1. Characteristic compressive strength at 28 days = 25 N/mm²
2. Target mean strength, F_{ck} = $25 + 1.65 \times 4 = 31.6$ Mpa
3. Maximum size of aggregate = 20mm
4. Degree of workability = 0.8CF
5. Degree of quality control = GOOD
6. Type of exposure = Mild

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B. Test data for Materials:

- 1. Specific gravity of OPC 53 grade = 3.09
- 2. Specific gravity of coarse aggregate = 2.59
- 3. Specific gravity of sand = 2.56
- 4. Fineness modulus of fine aggregate = 3.38
- 5. Fineness modulus of coarse aggregate = 7.36
- 6. Free (surface) moisture coarse aggregate Nil
- 7. Specific gravity of PEG 400 = 1.126

Required sand content Percentage of total aggregate by absolute volume } = 35-2.5
 Required water content } = 32.5%
 } = 186kg/m³

1Cement content = 391.578Kg/m³

Fine aggregate:

$$V = (W + C/S_C + 1/P \times F_a/S_{fa}) \times (1/1000)$$

$$0.98 = (186 + 391.57/3.09 + (1/0.325) \times F_a/2.56) \times (1/1000)$$

$$F_a = 555.175\text{kg/m}^3$$

Coarse aggregate

$$V = (W + C/S_C + 1/(1-P) \times C_a/S_{ca}) \times (1/1000)$$

$$0.98 = (186 + 391.57/3.09 + 1/(1-0.325) \times C_a/2.59) \times (1/1000)$$

$$C_a = 1166.56\text{kg/m}^3$$

MIX PROPORTION:

Water	Cement	Fine aggregate	Coarse aggregate
186kg/m ³	392kg/m ³	555kg/m ³	1167kg/m ³
0.475	1	1.42	2.98

Table No.1: POLYETHYLENE GYLCOL is added according to the percentages (i.e, 0%, 0.5%, 1%, 1.5 and2%) with weighing the weight of cement.

Quantity of Concrete Required for Cube (M₂₅) Grade concrete:

- Volume of cube = 0.15 x 0.15 x 0.15
= 3.375 x 10⁻³ m³.
- Total density = 2300kg/m³
- Weight of concrete/cube = 3.375 x 10⁻³ x 2113.30
= 7.76kg
- Wastage = 15
= 1.15 x 7.76
= 8.92kg
- Cement required/cube = (1/5.875) x 8.92
= 1.519kg
- F.A required/cube = 1.519 x 1.42
= 2.155kg

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$$\begin{aligned} \text{C.A required/cube} &= 2.98 \times 1.519 \\ &= 4.524\text{kg} \\ \text{Water required/cube} &= 0.721\text{litres} \end{aligned}$$

Quantity of Concrete Required for Cylinder (M₂₅) Grade concrete:

$$\begin{aligned} \text{Volume of cylinder} &= (\pi \times 0.15^2/4) \times 0.3 \\ &= 5.301 \times 10^{-3} \text{ m}^3 \\ \text{Total density} &= 2299.30\text{kg/m}^3 \\ \text{Weight of concrete/cylinder} &= 2299.30 \times 5.301 \times 10^{-3} \\ &= 12.188\text{kg} \\ \text{Wastage} &= 15\% \\ &= 1.15 \times 12.188 \\ &= 14.016\text{kg} \\ \text{Cement required/cylinder} &= (1/5.875) \times 12.188 \\ &= 2.074\text{kg} \\ \text{F.A required/cube} &= 2.074 \times 1.42 \\ &= 2.94\text{kg} \\ \text{C.A required/cube} &= 2.98 \times 2.074 \\ &= 6.184\text{kg} \\ \text{Water required} &= 0.98\text{litres} \end{aligned}$$

B. Mix design by method for M₃₅ Grade Concrete:

A. Design Stipulations:

- | | | |
|---|---|--------------------------------|
| 1. Characteristic compressive strength at 28 days | } | = 35 N/mm ² |
| 2. Target mean strength, F _{ck} | } | = 35 + 1.65 × 5
= 43.25 Mpa |
| 3. Maximum size of aggregate | | = 20mm |
| 4. Degree of workability | | = 0.8CF |
| 5. Degree of quality control | | = GOOD |
| 6. Type of exposure | | Mild |

Test data for Materials:

- | | | |
|--|---------|---------------------------|
| 1. Specific gravity of OPC 53 grade | = 3.09 | |
| 2. Specific gravity of coarse aggregate | = 2.59 | |
| 3. Specific gravity of sand | = 2.56 | |
| 4. Fineness modulus of fine aggregate | = 3.38 | |
| 5. Fineness modulus of coarse aggregate | = 7.36 | |
| 6. Free (surface) moisture coarse aggregate | Nil | |
| 7. Specific gravity of PEG 400 | = 1.126 | |
| Required sand content Percentage of total aggregate by absolute volume | } | = 36-2.5
= 33.5% |
| Required water content | } | = 186kg/m ³ |
| Cement content | } | = 489.47Kg/m ³ |

Fine aggregate:

$$\begin{aligned} V &= (W + C/S_C + 1/P \times F_a/S_{fa}) \times (1/1000) \\ 0.98 &= (186 + 489.47/3.09 + 1/0.325 \times F_a/2.56) \times (1/1000) \\ F_a &= 528.81\text{kg/m}^3 \end{aligned}$$

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Coarse aggregate:

$$V = (W + C/S_C + 1/(1-P) \times C_a/S_{ca}) \times (1/1000)$$

$$0.98 = (186 + 489.47/3.09 + 1/(1-0.325) \times C_a/2.59) \times (1/1000)$$

$$C_a = 1111.178 \text{ kg/m}^3$$

MIX PROPORTIONS

Water	Cement	Fine aggregate	Coarse aggregate
186kg/m ³	490kg/m ³	529kg/m ³	1111kg/m ³
0.38	1	1.08	2.27

Table No.2: POLYETHYLENE GLYCOL is added according to the percentages (i.e, 0%, 0.5%, 1%, 1.5 and 2%) with weighing the weight of cement.

Quantity of concrete Required for cube M35 Grade Concrete:

$$\begin{aligned} \text{Volume of cube} &= 0.15 \times 0.15 \times 0.15 \\ &= 3.375 \times 10^{-3} \text{ m}^3. \\ \text{Total density} &= 2316 \text{ kg/m}^3 \\ \text{Weight of concrete/cube} &= 3.375 \times 10^{-3} \times 2307 &= 7.82 \text{ kg} \\ \text{Wastage} &= 15\% \\ &= 1.15 \times 7.82 \\ &= 9.0 \text{ kg} \\ \text{Cement required/cube} &= (1/4.73) \times 7.82 \\ &= 1.66 \text{ kg} \\ \text{F.A required/cube} &= 1.66 \times 1.08 \\ &= 1.787 \text{ kg} \\ \text{C.A required/cube} &= 2.27 \times 1.66 \\ &= 3.758 \text{ kg} \\ \text{Water required/cube} &= 0.63 \text{ litres} \end{aligned}$$

Quantity of Concrete Required for Cylinder (M35) Grade concrete :

$$\begin{aligned} \text{Volume of cylinder} &= (\pi \times 0.152^2/4) \times 0.3 \\ &= 5.301 \times 10^{-3} \text{ m}^3 \\ \text{Total density} &= 2316 \text{ kg/m}^3 \\ \text{Weight of concrete/cylinder} &= 2316 \times 5.301 \times 10^{-3} \\ &= 12.272 \text{ kg} \\ \text{Wastage} &= 15\% \\ &= 1.15 \times 12.272 \\ &= 14.11 \text{ kg} \\ \text{Cement required/cylinder} &= (1/4.73) \times 12.272 \\ &= 2.59 \text{ kg} \\ \text{F.A required/cube} &= 2.59 \times 1.08 \\ &= 2.802 \text{ kg} \\ \text{C.A required/cube} &= 2.59 \times 2.27 \\ &= 5.89 \text{ kg} \\ \text{Water required} &= 0.986 \text{ liters} \end{aligned}$$

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IV. RESULTS AND DISCUSSION

Table no – 3 Experimental program

S.NO	% of PEG 400	MIX PROPORTION		W/C RATIO		NO. OF CUBES		NO. OF CYLINDERS	
		M ₂₅	M ₃₅	M ₂₅	M ₃₅	M ₂₅	M ₃₅	M ₂₅	M ₃₅
		1	0%	1:1.42:2.98	1:1.08:2.27	0.475	0.38	3	3
2	0.50%	1:1.42:2.98	1:1.08:2.27	0.475	0.38	3	3	3	3
3	1%	1:1.42:2.98	1:1.08:2.27	0.475	0.38	3	3	3	3
4	1.50%	1:1.42:2.98	1:1.08:2.27	0.475	0.38	3	3	3	3
5	2%	1:1.42:2.98	1:1.08:2.27	0.475	0.38	3	3	3	3

Table no - 4 Specimen details

MOULD TYPE	DIMENSIONS (mm)	NO.OF CUBES CASTED PER DAY PER MIX	
		7 DAYS	28 DAYS
		CUBE	150 x 150 x 150
CYLINDER	150 Dia x 300 Height	3	3

Table no – 5 Average Cube Compressive Strength “F_{ck} (N/sq.mm)” of M₂₅ Grade Concrete.

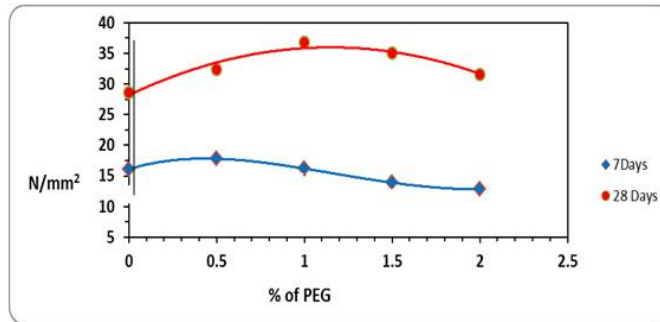
Average Cube Compressive Strength of M ₂₅ Grade Concrete						
S.NO		1	2	3	4	5
% OF PEG-400		0	0.5	1.0	1.5	2
AVERAGE COMPRESSIVE STRENGTH	7DAYS	16.1	17.8	16.2	13.9	12.8
	28DAYS	28.6	32.4	36.8	35.1	31.6

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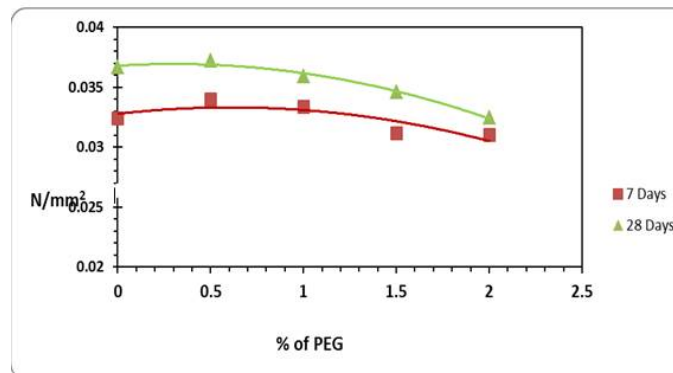
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Graph 1: Graphical Representation of the Compressive Strength of M₂₅ grade Concrete at various percentages of PEG-400

Table no – 6 Average Cube Compressive Strength “F_{ck} (N/sq.mm)” of M₃₅ Grade Concrete.

Average Cube Compressive Strength of M ₃₅ Grade Concrete						
S.NO	1	2	3	4	5	
% OF PEG-400	0	0.5	1.0	1.5	2	
Average Cube Compressive Strength	7DAYS	32.38	35.23	33.34	31.121	30.98
	28DAYS	36.65	37.23	35.93	34.62	32.44



Graph 2: Graphical Representation of the Compressive Strength of M₃₅ grade Concrete at various percentages of PEG-400.

Table no- 7 Average Split Tensile Strength (F_t- N/mm²) M₂₅ Grade Concrete

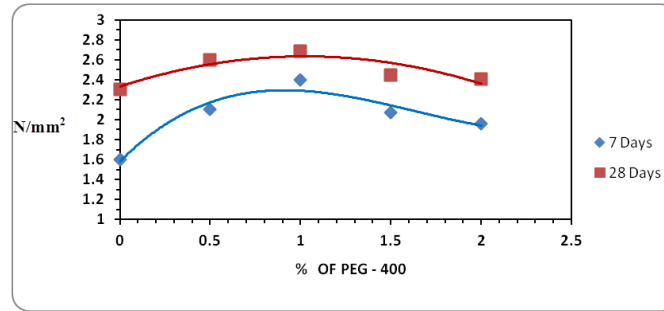
Average Split Tensile Strength of M ₂₅ Grade Concrete						
S.NO	1	2	3	4	5	
% OF PEG-400	0	0.5	1	1.5	2	
Average Split Tensile Strength	7DAYS	1.6	2.1	2.4	2.07	1.96
	28DAYS	2.3	2.6	2.69	2.45	2.41

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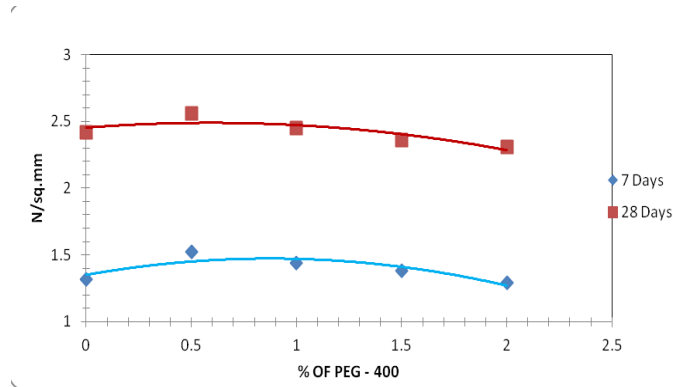
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Graph -3 Graphical Representation of the Split Tensile Strength of M₂₅ grade Concrete at various percentages of PEG-400

Table no- 8 Average Split Tensile Strength (F_t- N/mm²) M₃₅ Grade Concrete

Average Split Tensile Strength of M ₃₅ Grade Concrete						
S.NO		1	2	3	4	5
% OF PEG-400		0	0.5	1	1.5	2
Average Split Tensile Strength	7DAYS	1.32	1.52	1.44	1.38	1.29
	28DAYS	2.42	2.56	2.45	2.36	2.31



Graph -4 Graphical Representation of the Split Tensile Strength of M₃₅ grade Concrete at various percentages of PEG-400

Table no- 9a: NaCl Absorption test at 24 hours of M₂₅ Grade Concrete

% of PEG-400	Weight of cube(kg)	% of Increase or Decrease
0	8.37	-----
0.5	8.41	0.48
1.0	8.39	0.24
1.5	8.42	0.60
2.0	8.48	1.31

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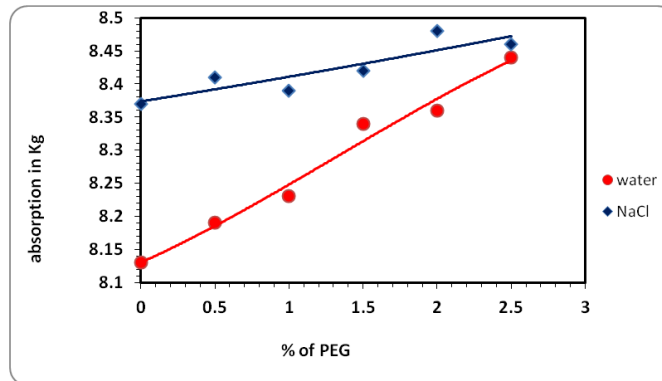
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Table no- 9b: Water Absorption test at 24 hours of M₂₅ Grade Concrete.

% of PEG-400	Weight of cube(kg)	% of Increase or Decrease
0	8.13	-----
0.5	8.19	0.74
1.0	8.23	1.23
1.5	8.34	2.58
2.0	8.36	2.83



Graph -5 Graphical Representation of Water and Acid(NaCl) Absorption test of M₂₅ Grade Concrete at various percentage of PEG-400

Table no- 10a: NaCl Absorption test at 24 hours of M₃₅ Grade Concrete

% of PEG-400	Weight of cube(kg)	% of Increase or Decrease
0	8.52	-----
0.5	8.6	0.94
1.0	8.69	2.0
1.5	8.76	2.82
2.0	8.82	3.42

Table no- 10b: Water Absorption test at 24 hours of M₂₅ Grade Concrete.

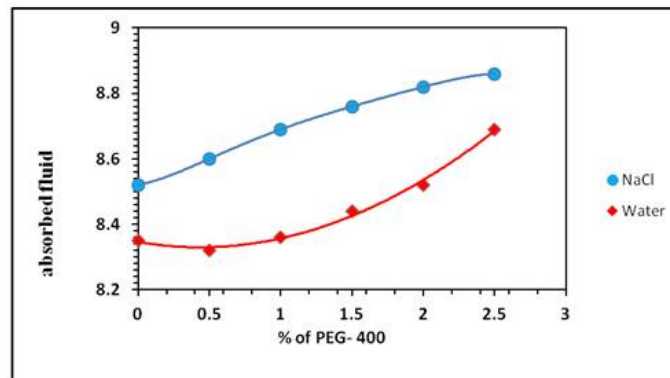
% of PEG-400	Weight of cube(kg)	% of Increase or Decrease
0	8.35	----
0.5	8.29	-0.72
1.0	8.36	0.12
1.5	8.44	1.08
2.0	8.52	2.01

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Graph -6 Graphical Representation of Water and Acid(NaCl) Absorption test of M₃₅ Grade Concrete at various percentage of PEG-400

IV. CONCLUSION

- a) Due to use of PEG 400
 1. Effectiveness of self-curing concrete is affected by w/c ratio and percentage dosages of self-curing agent.
 2. The workability of concrete with low w/c ratio together with super-plasticiser has significant effect due to lower molecular weight polyethylene glycol (PEG 400).
 3. The compressive strength of concrete with low w/c ratio has significant effect due to change in curing regime.
 4. The optimum dosage of PEG 400 for maximum compressive strength was found to be 1% for M25 0.5% for M35 grades of concrete.
 5. As % of PEG 400 increased slump increased for both M25 and M35 grades of concrete.
- b) Comparative Study
 1. The compressive strength of concrete with low w/c ratio and lower dosages of self-curing agents is beneficial.
 2. Low grade concrete with 1% dosage of PEG400 shows good compressive strength.

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