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# COMPARATIVE STUDY AND COST ANALYSIS ON CURING AGENTS FOR SELF CURING CONCRETE

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***Abstract:*** Curing of concrete is the process of maintaining satisfactory moisture content in concrete during its early stages to develop the desired properties. However good curing is not always practical in many cases the present study deals with the effect of polyethylene glycol (PEG)and poly-vinyl alcohol (PVA) on concrete and their contribution to strength which are carried out. The effect of admixtures in mechanical characteristic of concrete i.e., compressive strength, split tensile strength by varying the percentage of PVA and PEG-400 from 0% to 2.5% by weight of cement is studied for M30 grade of concrete and the optimum percentage of PEG and PVA in self-curing concrete with conventional concrete with water curing is compared. The optimum percentage with PEG is coated with PVA and strength analysis is done. Curing is one of the most important factors for achieving maximum desirable strength in concrete, concrete should be cured properly so that it is fully hydrated and loss of moisture inside the concrete should be reduced. Poly vinyl alcohol and polyethylene glycol-400 is locally available chemical which can be used as a self-curing agent in concrete so that moisture in the concrete can be maintained and concrete can be fully hydrated.

***Index Terms* -** Self-curing concrete, polyethylene glycol, poly-vinyl alcohol, $M_{30}$ grade.

## I. INTRODUCTION

Concrete curing is a crucial step in construction, allowing the concrete to develop strength, reduce shrinkage, and create a durable structure. It is a process where hydraulic cement concrete hardens over time, requiring sufficient water and heat. Water is necessary for the hydration reaction, converting gray cement powder into binding cement paste, which gives concrete its strength. If excessive water evaporation from fresh concrete is not avoided, it can lead to unsatisfactory properties. In civil engineering, curing is essential for maintaining moisture content and temperature, allowing the properties of concrete to expand.

In the early stages of concrete curing, the use of polythene glycol and polyvinyl alcohol can reduce water loss and enhance water preservation capacity. Proper hydration in concrete requires a relative humidity of about 80%. Self-curing concrete, which dissipates less water, increases the hydration process, quality improvement, decreased autogenous shrinkage and splitting, decreased permeability, and expanded durability. In hot climates and areas lacking water, self-curing concrete is the most suitable solution for achieving desired strength without loss.

**Curing:** Curing is the process of controlling the moisture transport from concrete during cement hydration, either after placement or during manufacturing. It is crucial for achieving potential strength and durability in concrete. Curing may also involve temperature control, as it affects the rate of cement hydration. The curing period depends on the concrete's properties, purpose, and ambient conditions. The primary goal is to keep the concrete moist by preventing moisture loss during the strength gain period.

**Self-Curing:** Curing concrete is crucial for maintaining moisture content and achieving desired properties. However, good curing is not always practical, leading researchers to explore self-curing agents. These agents reduce water evaporation from concrete, increasing its water retention capacity. Water-soluble polymers can be used as self-curing agents in concrete. This trend in concrete construction is expected to improve durability and performance. Curing plays a major role in developing the concrete microstructure and pore structure, and excessive water evaporation should be avoided to maintain cement hydration and prevent unsatisfactory properties. This investigation discusses achieving optimum concrete cure without external curing methods and the effect of self-curing techniques on high-performance concrete properties. The use of self-curing admixtures is important for the modern concrete industry, as water resources are becoming valuable daily.

## II. LITERATURE REVIEW

Literature is a broad term for a lot of different written works that reflect human thoughts, feelings*, and imagination. Literature,* from epics from long ago to modern novels, poems, and plays, shows different cultures, points of view, and ideas. It shows how society is and encourages people to think critically, care about others, and be creative. With its complicated language, literature has always been a way for people of all ages to find inspiration, have fun, and challenge their minds.

**El-Dieb (2007):** The study examined the effects of self-curing agents on water retention, hydration, water absorption, permeable pores, and water absorptivity in concrete. Results showed that SCC improved hydration compared to conventional concrete, while PAM and PEG improved water retention and hydration in mixes with 8% silica fume cement replacement.

**El-Dieb (2012):** The study examined the impact of polyacrylamide (PAM) and polyethylene glycol (PEG) as self-curing agents on the hydration, water retention, permeable pores, water absorption, and microstructural characteristics of Portland cement mixes with 8% silica fume and without silica fume as cement replacement. Results showed that PAM and PEG improved water retention and hydration in mixes with silica fume cement replacement, resulting in denser microstructures.

**Junaid et. al. (2015):** The study compared conventional cured concrete and self-curing concrete using polyethylene glycol (PEG-4000) admixture. The self-curing concrete showed better hydration and strength, with 1% PEG-4000 cured concrete achieving more compressive strength.

**Abhishek et. al (2015)** The study found that the optimal dosage of super absorbent polymer (SAP) for maximum compressive strength in self-curing concrete is 0.3%.

**Aneel kumar et al. (2021):** The study shows that as the dose of polyvinyl alcohol increases, the workability of self-curing concrete increases, but there is no significant increase in compressive strength compared to conventional concrete.

**Waleed A. Abbas et al. (2019):** The study demonstrated that self-curing cement mortar composites modified with polyvinyl alcohol showed enhanced mechanical properties, including increased tensile and compressive strength, after 28 days of dry conditions.

**Mrs. Roopakala C. G et al. (2021):** Experimental study on properties of self-curing concrete incorporated with PEG and PVA, From compressive strength, splitting tensile strength and flexural strength test results, it was found that self curing concrete has more strength results than that was found in water cured concrete.

**Prakash Mandiwal et al.(2018):** The experimental study on the use of Polyethylene Glycol as a self-curing agent in self-curing concrete found that it achieved a maximum strength of 1.6% for Mix-25 and 2.4% for Mix-20.

**Mr. Dhanush V S (2021):** Self-curing concrete offers high strength, water-saving properties, and low cost compared to conventional concrete. Its internal curing with PEG-400 provides better results and lower water requirements compared to external curing

## III. OBJECTIVES

- To study the mechanical characteristic of concrete i.e., compressive strength, split tensile strength by varying the percentage of Polyethylene Glycol-400 and Polyvinyl Alcohol from 0% to 2.5% by weight of cement.
- To study the mechanical characteristic of concrete i.e., compressive strength, split tensile strength by varying the percentage of Polyvinyl Alcohol from 0% to 2.5% by weight of cement.
- Determine the strength of normal concrete & self-curing concrete & compare them. Comparative study and cost analysis on curing agents like Polyethylene Glycol-400 And Polyvinyl Alcohol.

## IV. MATERIALS AND METHODS

### 4.1 Materials Used:

**Cement** is a binder that sets and hardens independently, forming strong building materials like motor and concrete. It bonds natural or artificial aggregates to form durable materials. The 53 grade OPC conforming to IS: 12269-2013 is used. The strength of ordinary Portland cement comes from chemical reactions between cement and water, known as hydration. Understanding the chemical composition of cement is crucial for understanding this complex process.

**Table 4.1 Chemical Composition of Cement**

| COMPOUND | FORMULA | MASS % |
|---|---|---|
| Tri-calcium Silicate | $C$3S | 56-60 % |
| Silicon dioxide | $SiO_2$ | 19-23 % |
| Aluminium oxide | $Al_2O_3$ | 2.5-6 % |
| Iron oxide | $Fe_2O_3$ | 0-6 % |
| Sulphate | 3 | 1.5-4.5 % |

**Fine aggregate**, a material passing through a 4.75mm IS sieve, is used to fill voids in coarse aggregate and act as a workability agent. M-sand is used as fine aggregate, which is clean, nearly impurity-free, and conforms to zone II of IS: 383-1970.

**Course aggregate** The aggregate used in concrete works should be cubicle, rounded, and have a smooth, non-powdery surface. Flat, elongated, flaky, or mica aggregates should be rejected. Coarse aggregates should be gradated according to IS-383 specifications, and after 24 hours of immersion in water, a perversely dried sample should not gain weight more than 5%.


**Figure 4.1 (a) cement, (b) fine aggregate, (c) course aggregate**

**POLYETHYLENE GLYCOL-400:** The experimental utilized Polyethylene Glycol-400, a clear liquid with a water-soluble nature, consisting of polymers with varying molecular weights.

**Table 4.2 Properties of Polyethylene Glycol-400**

| Sl. No. | PROPERTY | VALUE |
|---|---|---|
| 1 | Appearance | Clear Liquid |
| 2 | Odour | Nil |
| 3 | Specific Gravity | 1.09 |
| 4 | PH | 5-7 |
| 5 | Molecular Weight | 400 |
| 6 | Density | 1.128 $g/cm^3$ |

**POLYVINYL ALCOHOL** Polyvinyl Alcohol, a water-soluble synthetic polymer, is a translucent, white, odorless, tasteless compound with high tensile strength, flexibility, and excellent film-forming properties, derived from Polyethylene Glycol.

**Table 4.3 Properties of polyvinyl alcohol**

| Sl. No. | PROPERTY | VALUE |
|---|---|---|
| 1 | Appearance | Cristal |
| 2 | Odour | Nil |
| 3 | Specific Gravity | 1.2-1.3 |
| 4 | PH | 5.0-6.5 |
| 5 | Molecular Weight | 26,300-30,000 |
| 6 | Density | 1.19 $g/cm^3$ |

**Figure 4.2 (a) polyethylene glycol-400 (b) polyvinyl alcohol**

**Super-plasticizer** is a chemical additive in concrete that enhances its workability without affecting its water-cement ratio, thereby reducing water content while maintaining fluidity and strength.

**Water:** The experimental work utilized potable water for mixing, laying, compaction, setting, and hardening concrete, highlighting its crucial role in the strength of the concrete, specifically within the college campus water.

**4.2 Experimental Techniques:**

The experimental program was designed to investigate the strength of internally cured concrete by adding polyethylene glycol PEG-400 and polyvinyl alcohol PVA @ 0%, 0.5%, 1.5% and 2.5% by weight of cement to the concrete.

**Specific gravity** is crucial in mix design, defined as the ratio between material mass and water mass. To determine cement's specific gravity, water-free kerosene is used, which does not react with cement. The specific gravity of kerosene is 0.78, and can be determined using a specific gravity bottle or a standard le-chatelier flask.

**Fitness test:** As per IS: 4031 (Part 1) – 1996. The cement of good quality should have less than 10% of residue particles larger than 90 µm.

**Consistency:** For finding the normal consistency of cement As per IS: 4031-PART 4 -1988 VICAT APPARATUS test is performed.

**Initial and final setting time:** The initial setting time is the time between adding water to cement and the needle failing to penetrate the test block by 5-7 mm. It is measured using the standard VICAT apparatus and refers to the time when cement paste loses its plasticity and becomes hard.

**Sieve analysis** helps to determine the particle size distribution of the fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963.

**Water absorption test,** the aggregates are dried in oven for a specified time and temperature and then placed in a desiccators to cool. The material is then emerged in water at agreed upon conditions, often for 24 hours.

**V. RESULTS AND DISCUSSIONS**

**Specific gravity of cement:**

| Sl No | $W_1$ | $W_2$ | $W_3$ | $W_4$ | Specific gravity |
|---|---|---|---|---|---|
| 1 | 34.4 | 81.4 | 109.5 | 74.4 | 3.159 |
| 2 | 34.4 | 82.4 | 110.2 | 74.4 | 3.147 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 34.4 | 81.4 | 109.4 | 74.4 | 3.130 |

$W_1 \rightarrow$ Weight of empty density bottle;

$W_2 \rightarrow$ Weight of the density bottle +1/3$^{rd}$of cement;

$W_3 \rightarrow$ Weight of the density bottle +1/3$^{rd}$ cement + kerosene;

$W_4 \rightarrow$ Weight of the density bottle + full of kerosene;

**Specific gravity of fine aggregate:**

| Sl No | $W_1$ | $W_2$ | $W_3$ | $W_4$ | Specific gravity |
|---|---|---|---|---|---|
| 1 | 506 | 958 | 1823 | 1535 | 2.75 |
| 2 | 506 | 921 | 1806 | 1535 | 2.72 |
| 3 | 506 | 934 | 1809 | 1535 | 2.77 |

$W_1 \rightarrow$ Empty weight of pycnometer;

$W_2 \rightarrow$ Weight of the pycnometer +1/3$^{rd}$of sand;

$W_3 \rightarrow$ Weight of the pycnometer +1/3$^{rd}$ sand + water;

$W_4 \rightarrow$ Weight of the pycnometer + water;

**Finess of Cement:**

| Sl No | Description | Trail 1 |
|---|---|---|
| 1 | Weight of cement $W_1$ grams | 100 |
| 2 | Weight of cement retained on 90 micron IS sieve W2 | 7 |
| | Fitness of cement $\% = \frac{W_2}{W_1} *$ 100 | 7% |

**Standard consistency test:**

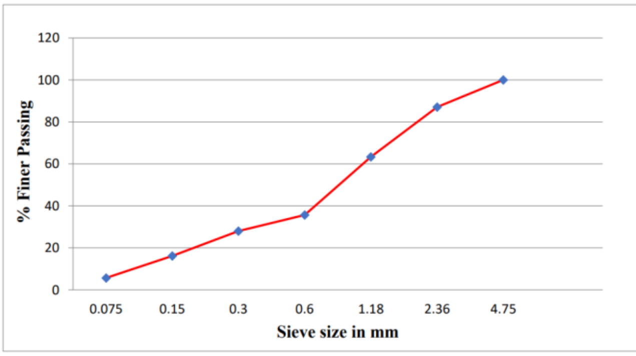
| Trial No | % of Water | Vol of water (ml) | Initial reading (mm) | Final reading (mm) | Depth (mm) |
|---|---|---|---|---|---|
| 1 | 24 | 96 | 40 | 40 | 0 |
| 2 | 26 | 104 | 40 | 38 | 2 |
| 3 | 28 | 112 | 40 | 26 | 14 |
| 4 | 30 | 120 | 40 | 13 | 27 |
| 5 | 32 | 128 | 40 | 6 | 34 |

**Setting Time:**

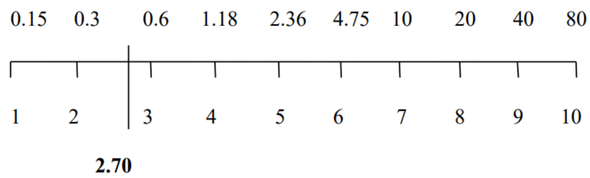
| Trial No | Time in minutes | Initial reading (mm) | Final reading (mm) | Depth (mm) |
|---|---|---|---|---|
| 1 | 5 | 40 | 0 | 40 |
| 2 | 10 | 40 | 0 | 40 |
| 3 | 15 | 40 | 0 | 40 |
| 4 | 25 | 40 | 0 | 40 |
| 5 | 30 | 40 | 0 | 40 |
| 6 | 35 | 40 | 1 | 39 |
| 7 | 40 | 40 | 2 | 38 |
| 8 | 45 | 40 | 2 | 38 |
| 9 | 50 | 40 | 5 | 35 |
| 10 | 55 | 40 | 5 | 35 |

**Table 4 Sieve analysis of Fine Aggregate**

| Sieve size in mm | Weight retained in gms | % weight of sand retained in gms | Cumulative % of weight retained in gms | % of Finer passing in gms |
|---|---|---|---|---|
| 4.75 | 0 | 0 | 0 | 100 |
| 2.36 | 129 | 12.9 | 12.9 | 87.1 |
| 1.18 | 238 | 23.8 | 36.7 | 63.3 |
| 0.6 | 276 | 27.6 | 64.3 | 35.7 |
| 0.3 | 77 | 7.7 | 72.0 | 28.0 |
| 0.15 | 118 | 11.8 | 83.8 | 16.2 |
| 0.075 | 105 | 10.5 | 94.3 | 5.7 |
| Pan | 57 | 5.7 | 100 | 0 |




**Fineness modulus index:**




**Specific gravity of Course aggregate:**

| Sl No | $W_1$ | $W_2$ | $W_3$ | $W_4$ | Specific gravity |
|---|---|---|---|---|---|
| 1 | 501 | 840 | 1715 | 1500 | 2.733 |
| 2 | 501 | 870 | 1735 | 1500 | 2.58 |
| 3 | 501 | 860 | 1720 | 1500 | 2.75 |

$W_1 \rightarrow$ Empty weight of pycnometer;

$W_2 \rightarrow$ Weight of the pycnometer +1/3$^{rd}$of sample;

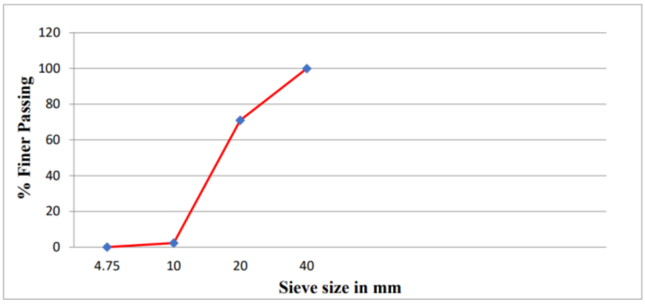
$W_3 \rightarrow$ Weight of the pycnometer +1/3$^{rd}$ sample + water;

$W_4 \rightarrow$ Weight of the pycnometer + water;

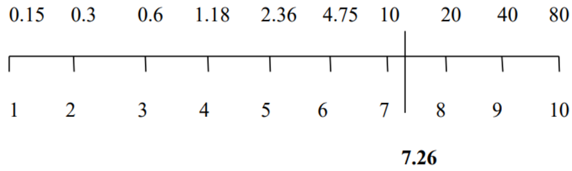
Table 5 Sieve analysis of Course Aggregate

| Sieve size in mm | Weight retained in gms | % weight of sand retained in gms | Cumulative % of weight retained in gms | % of Finer passing in gms |
|---|---|---|---|---|
| 40 | 0 | 0 | 0 | 100 |
| 20 | 579 | 28.95 | 28.95 | 71.05 |
| 10 | 1375 | 68.75 | 97.7 | 2.3 |
| 4.75 | 46 | 2.3 | 100 | 0 |

| | | | | |
|---|---|---|---|---|
| Pan | 0 | 0 | 0 | 0 |




**Fineness modulus index:**




**4.3 Results:**

The test results are obtained by keeping the mix proportions constant without any inclusion of plasticizers and super-plasticizers. Only curing compounds are additionally added in the mix as a substitute of curing water.

- The Strength of concrete achieved by conventional curing is at par as compared to internal curing methods. The results obtained from conventional curing method (ponding) are under ideal conditions when the specimens are kept completely submerged in water for 28 days. Such long and ideal curing conditions may not be possible under actual site conditions. Thus these results do not give a true picture of conditions existing at construction sites.
- Concrete mixes prepared using curing compounds are at par with specified target strength values calculated during design mix for $M_{20}$, $M_{25}$, $M_{30}$ and $M_{40}$ grade of concrete. Also it can be seen that more than the minimum strength as per the codal provisions has been achieved by the specimens cured through curing compounds. The strength achieved by liquid paraffin wax is comparable for different types of mix i.e. M20, M25, M30 and M40. The results obtained after the use of curing compounds show a better picture of the actual site conditions in comparison to those obtained from conventional curing techniques. Only the environmental conditions existing at site and laboratory may vary. Rest all parameters are more or less the same.
- The strength achieved cured through curing compound paraffin wax is nearly 99% of that achieved through conventional curing method for both $M_{20}$, $M_{25}$, $M_{30}$ and $M_{40}$ grade of concrete.
- The extra cost of procuring water from deep underground or far off sources specially in developing areas can be saved by the use of curing compounds.

## VI. CONCLUSION

1) As per the results compiled in Table 4.1 compressive strength of various mixes for M20, M25,M30 and M40 Grade of concrete we conclude that the compressive strength of mixes using self-curing compound Liquid paraffin wax are at par with that of the concrete with conventional curing.
2) The compressive strength achieved through curing compound LPW is nearly 99% of that achieved through conventional curing method for M20, M25, M30 and M40 grade of concrete.
3) It can be seen that the minimum strength as per the codal provisions has been achieved by the specimens cured through curing compounds. The strength achieved by the LPW is comparable for different types of mixes i.e. M20, M25, M30 and $M_{40}$. The results obtained after the use of curing compounds show a better picture of the actual site conditions in comparison to those obtained from conventional curing techniques.

## VII. REFERENCES

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