EXPERIMENTAL INVESTIGATION ON INTERNALLY CURED CONCRETE

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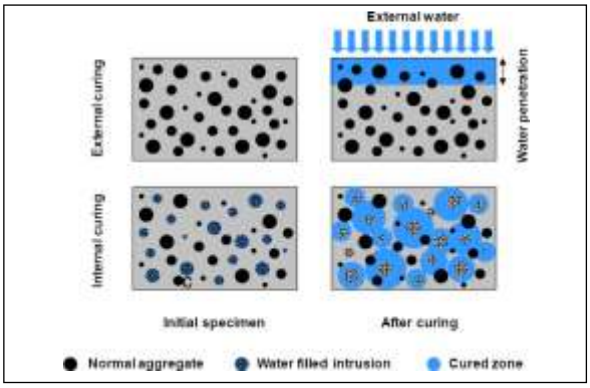
Abstract: Curing of concrete helps in preservation of satisfactory moisture in concrete during its initial stages, in order to develop the desired properties. However, congenial curing is not always practical in many cases. Several researchers and construction agencies have raised the question, whether there will be any self-curing agents for concrete. Therefore, the choice and methodology of using self-curing agents have attracted several researchers. The concept of self-curing agent is to reduce the water evaporation from concrete, and thereby 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.

In this research, the basic grade of concrete viz., M_{40} is studied for a trial analysis. Self-curing agents like Poly-Ethylene Glycol (PEG), and Liquid Paraffin Wax (LPW) are used for the present study.Here the dosage of Poly-Ethylene Glycol is fixed as 0.2%, 0.5% and 0.7%, and Liquid Paraffin Wax as 0.1%, 0.2% and 0.3% based on the weight of cement.

SIGNIFICANCE OF SELF-CURING CONCRETE

When the mineral admixtures react completely in a blended cement system, their ultimate requirement for curing water (external or internal) can be much higher than 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.

At present, there are only two major methods were available for internal curing of concrete. The first method uses saturated porous Light Weight Aggregate (LWA) in order to supply an internal storage of water, which can substitute the water consumed by chemical shrinkage during hydration. Another method involves the uses of water soluble polymers which reduces the rate of water evaporation from the surface of concrete and also helps in water retention. These are well added into the fresh concrete as a chemical admixture and hence known as internal curing compounds. They inhibit moisture loss and thereby improve long term strength and reduce drying shrinkage. Internal curing compounds are relatively new and care should be taken when utilised. They are used in tunnel linings and underground mines to provide at least partial curing, when traditional methods are difficult or even impossible to employ. Figure 1.1 explains the difference between external and internal curing.



(Source: Jason Weiss, Materials and Pavements, Oregon State University)

Figure 1 External and Internal curing

OBJECTIVE OF THE INVESTIGATION

The main objective of the research is as follows

1) To examine the properties such as workability of self-curing concrete with various dosage of curing agents such as PEG, and LPW with fixed

percentage of self-compacting agent.

2) To determine the strength of SELF CURING and to compare it with conventionally cured concrete which involves immersion curing and sprinkler curing.

PROPERTIES OF MATERIALS USED IN SELF CURING CONCRETE

Cement: For the present investigation, Ordinary Portland cement of 53 grade confirm to IS: 12269 - 2013 is used. The cement is tested as per the codal procedures and the same is arrayed in Table 1.

Table 1 physical properties of OPC

Particulars	Result (%)	Requirements of IS: 12269 -2013
Physical Properties		
Fineness (m^2/kg)	325	Minimum 300
Normal consistency (%)	31%	--
Setting time (minutes)		
(a) Initial	47	Minimum 30
(b) Final	267	Maximum 600
Soundness		
(a) Le-chatlier expansion (mm)	1.0	Maximum 10.0
(b) Auto Clave expansion (%)	0.05	Maximum 0.8
Compressive Strength (MPa)		
3 days	29.06	Minimum 27.0
7 days	39.80	Minimum 37.0
21 days	54.50	Minimum 53.0

Fly Ash: Fly ash of Class F (as per ASTM C 618) collected from Kothadudam thermal power plant is used and the tests are conducted with the facilities in the laboratory under room temperature. The results are given in Table 2.

Table 2 Physical properties of Fly Ash

Properties	Test values
Physical form	Powder form

Specific surface area (cm^2/g)	3200
Bulk Density (kg/m^3)	750
Specific Gravity	2.6

Fine aggregate: For the present investigation, the natural river sand with fraction passing through 4.75mm and retained on 600µm sieve from the locally available Krishna River is used as a fine aggregate. The sand is washed and screened at the site to remove deleterious materials and tested as per the procedure given in IS: 2386-1963.

Table 3 Physical properties of fine aggregate

Properties	Values
Size	Passing through 4.75mm
Fineness Modulus	3.225
Water Absorption	1%
Bulking of sand - Max % of bulking - Corresponding water content for max% of bulking	22.8% 4%
Specific gravity	2.54
Void ratio	0.55
Bulk density	1770 kg/m^3

Coarse aggregate: The coarse aggregate is the strongest and least porous component of concrete. As far as the shape of the aggregate is concerned, crushed granite coarse aggregate provides better interlocking and hence it helps to achieve higher strength than rounded gravel aggregate. The coarse aggregate meeting the requirements of IS: 383-1970 is suitable for making SELF CURING.

Table 4 Physical properties of Coarse Aggregate

Properties	Values
Size	20mm

Fineness Modulus	7.3
Water Absorption	0.5 %
Specific gravity	2.6

Poly-Ethylene Glycol:

Poly-Ethylene Glycol means a condensation polymer of ethylene oxide and water with the general formula H $(OCH_2CH_2)_nOH$, where „n‟ is the average number of repeating oxyethylene groups typically ranging from 4 to about 180. The specific gravity is found to be 1.12-1.13. The hydroxyl value is 535-590 (mg KOH/g) and the pH value is between 5 and 7. PEG is a liquid chemical available in the market and is just added at trial percentage of 0.2%, 0.5% and 1% based on weight of cement, to the concrete at the time of mixing water. It was found that the increase in melting point of PEG occurs with increase in molecular weight. Here for the present investigation, PEG having molecular weight 600 is chosen based on melting point for a design room temperature under analysis. The PEG 600 is purchased from M/s. SD Fine Chemicals Pvt. Ltd, Hyderabad, India.

Figure 2 Image showing PEG 600

Liquid paraffin wax:

Paraffin wax is a white material which is a pure solid (or) in the form of pellets like nature. Here, the designed percentage of material is used based on weight of cementitious materials. Figures 3.8 and 3.9 shows the exact form of pellets breaks down into pieces and are then to converted into solution form, to benefit the concrete to enhance internal curing effect by holding and release the water for long term to upgrade better hydration. The paraffin wax in pellets form is purchased from M/s. Megha Group of companies, Hyderabad, India.

Figure 3 Paraffin wax in pellets form

MIX PROPORTIONS

Based on the above calculations, the mix proportions of self-curing concrete M40 grade are as follows:

- Cement: 400 kg/m3
- Water: 160 kg/m3
- Fine Aggregate (Sand): 715 kg/m3
- Coarse Aggregate (20mm): 1070

RESULTS AND DISCUSSIONS

Workability: The workability of fresh concrete was found using the slump cone apparatus as per the specifications of IS 7320-1974. The internal surface of the slump cone was cleaned and was filled with concrete in four layers. Each layer was tamped 25 times by the rod. The mold was cautiously removed vertically after striking off the excess concrete from the top layer with a trowel. The height of the slump was measured in mm.

Table 4 Workability Of Concrete With Poly-Ethylene Glycol

Curing agent PEG	Workability (mm)
0%	10
0.2%	10
0.5%	25
0.7%	15
Curing agent LPW	**Workability (mm)**
0%	10
0.1%	20
0.2%	25
0.3%	30

Compressive Strength Properties

The compressive strength of cube is tested for all the four mixes for a trial, based on IS specifications. Each mix is analyzed for the hardened natures with internal curing agents added at various types and dosages. Each type and dosage is compared with all other types of curing agents, and the concrete without any curing agent. Finally, the effective percentage of the mix is examined and analyzed for other interior properties.

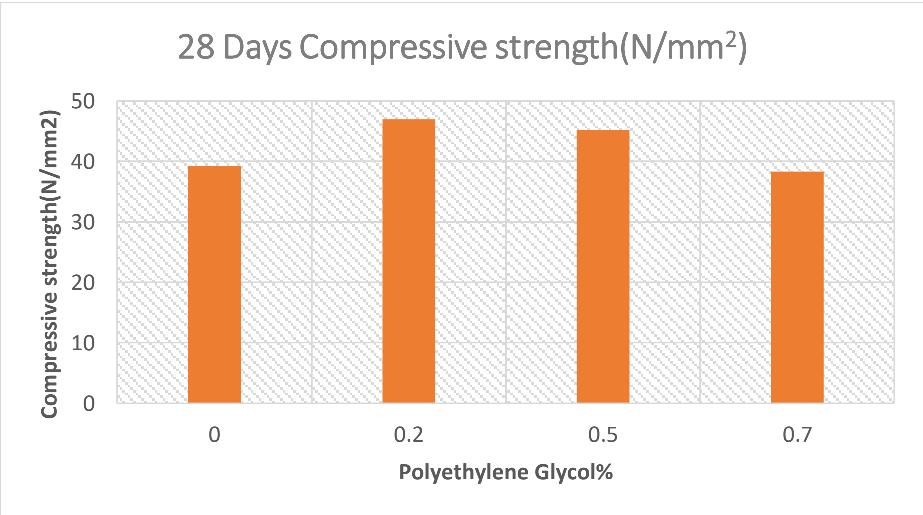


Figure 4 PEG Dosages vs. 28 Days Compressive Strength

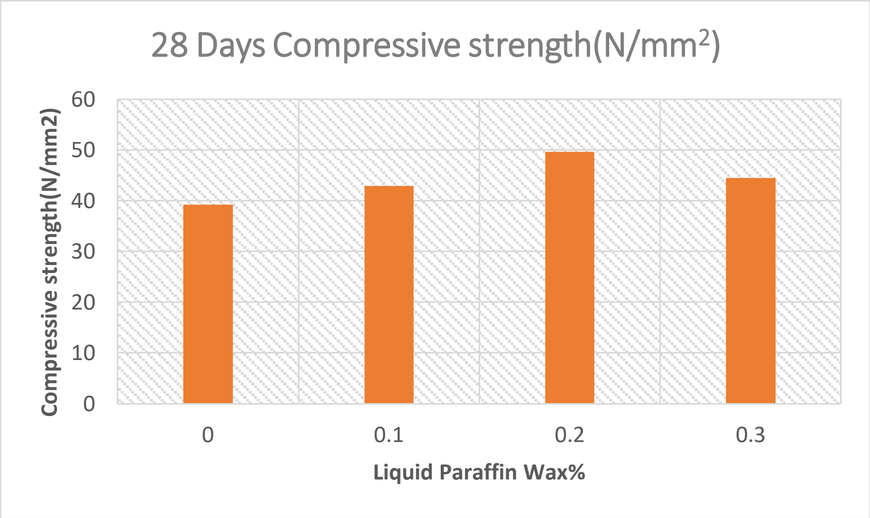


Figure 5. LPW Dosages vs. 28 Days Compressive Strength

Split Tensile Strength Properties

The lateral splitting strength of cylinder is tested for all the four mixes for a trial based on IS specifications. Each mix is analyzed for the resistance to lateral failure for the specimens with internal curing agents added at various types and dosages. Each type and dosage is compared with all other types of curing agents, and the concrete without any curing agent. Finally, the effective percentage of the mix is examined and analyzed for other interior properties.

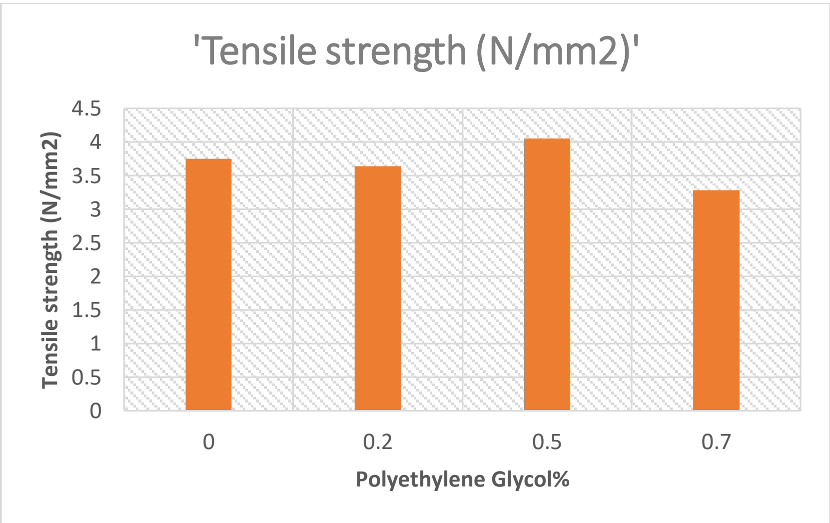


Figure 6 PEG Dosages vs. 28 Days Split Tensile Strength

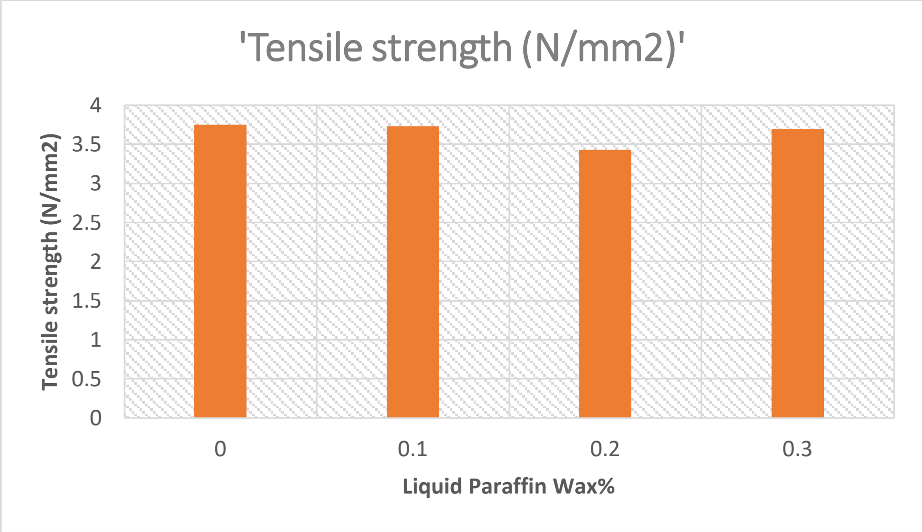


Figure 7 LPW Dosages vs. 28 Days Split Tensile Strength

Flexural Strength

The bending strength of prism is tested for all the four mixes for a trial based on IS specifications. Each mix is analyzed for the resistance to flexural failure for the specimens with internal curing agents added at various types and dosages. Each type and dosage is compared with all other types of curing agents, and the concrete without any curing agent. Finally, the effective percentage of the mix is examined and analyzed for other interior properties.

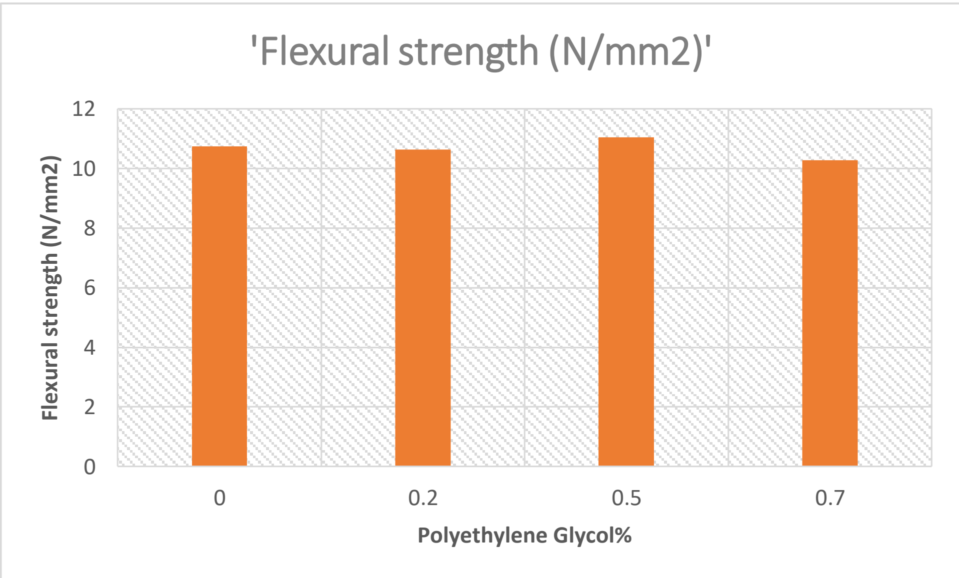


Figure 8 PEG Dosages vs. 28 Days Flexural Strength

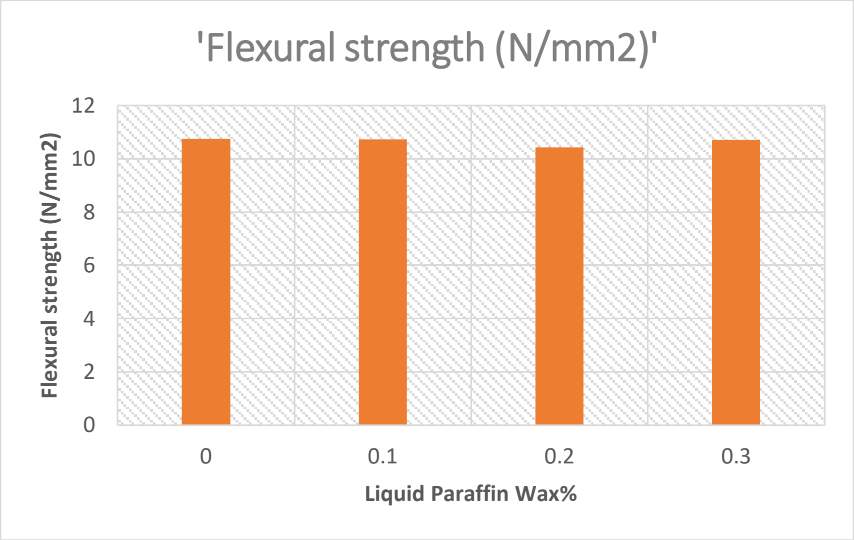


Figure 9 LPW Dosages vs. 28 Days Flexural Strength

CONCLUSIONS

- Compressive strength of all mixes with PEG 400 except one is found to be higher than that of the conventionally cured concrete.
- The best dosage of PEG 400 is found to be 0.2%.
- The optimal dosage of LPW is found to be 0.2% and the compressive strength attained at this dosage is 49.6 N/mm^2 which is 11.6% more than that of the conventionally cured concrete.
- All mixes with polyethylene glycol exhibited higher strength than the conventionally cured concrete.
- The optimal dosage of polyethylene glycol was 0.2% and the compressive strength at this dosage is 38.71 N/mm^2 which is 37.6% higher than that of the conventionally cured concrete.
- All mixes with liquid paraffin wax exhibited higher compressive strength than the conventionally cured concrete.
- PEG400 and LPW are identified as best self-curing agents.

REFERENCES

[1] Chand M.S.R., Giri P.S.N.R, Kumar G.R. and Kumar P.R., 2014, Paraffin wax as an internal curing agent in ordinary concrete, *Magazine of Concrete Research*, 67, 82-88. DOI: https://doi.org/10.1680/macr.14.00192

[2] Mousa, M.I., Mahdy, M.G., Abdel-Reheeem A.H. and Yehia A.Z., 2014, Physical properties of self-curing concrete types; water retention and durability, *Alexandria Engineering Journal*, 54, 565-575. DOI: https://doi.org/ 10.1016/j.aej.2015.03.027.

[3] Jensen O.M. and Lura P., 2006, Techniques and materials for internal water curing of concrete. *Materials and Structures*, 39, 817-825. DOI:10.1617/s11527-006-9136-6.

[4] Sheela V., 2019, Strength and durability characteristics of concrete mixture with the addition of ground exfoliated vermiculate as internal curing agent, *Ph.D. thesis, Karunya Institute of Technology and Sciences*.

[5] Thrinath G., Sundara Kuma P., 2017, Eco-friendly Self-curing Concrete Incorporated with Polyethylene Glycol as Self- curing Agent, *International Journal of Engineering*, Vol 30, Issue 4, 473-478. DOI:10.5829/ije.2017.30.04a.03

[6] Venkateswarlu K., Deo S. V., Murmu M., 2021, Effect of Super absorbent polymer on workability, strength and durability of Self consolidating concrete, *International Journal of Engineering*, Vol 34, Issue 5, 1118-1128. DOI:10.5829/IJE.2021.34.05B.05