RESEARCH ARTICLE OPEN ACCESS

Self Curing Concrete and Its Inherentproperties

Stella Evangeline
M. B (M.Tech), Asst.Professor, Departmental Of Civil Engineering, Dadi Institute Of Engineering And Technology, Anakapalle, Visakhapatnam.

ABSTRACT
Today concrete is most widely used construction material due to its good compressive strength and durability. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tonnes (12 billion tons) every year. Depending upon the nature of work, the cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain and fresh concrete. 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 favorable to curing. Concrete is needed to be provided with 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. A water/cement ratio of about 0.38 would be required to hydrate all the particles of cement and also to occupy the space in gel pores.

SELF CURING CONCRETE:
Self-curing is also referred as Internal- Curing. Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence and also due to scarcity 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 following materials can provide internal water reservoirs:
Lightweight Aggregate (natural and synthetic, expanded shale)
Super-absorbent Polymers (SAP) (60-300 nm size)
SRA (Shrinkage Reducing Admixture) (propylene glycol type i.e. polyethylene-glycol or Polyvinyl alcohol)
In this paper the use of polyvinyl alcohol in self curing concrete is explained. The Compressive and tensile strength of self-curing concrete for 7 and 28 days is found out and compared with conventional concrete of similar mix design.

Index Terms: Self-curing concrete; Water retention; Relative humidity; Hydration; Absorption; Water permeability ;Polyvinyl acetate; Polyvinyl alcohol.

I. INTRODUCTION:

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 It was found that water soluble alcohols can be used as self curing agents in concrete. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day (i.e. each 1m3 of concrete requires about 3m3 of water for construction most of which is for curing).

II. MECHANISM OF SELF CURING CONCRETE:

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

III. 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.

IV. POTENTIAL MATERIALS FOR SELF CURING:

The following materials can provide internal water reservoirs:

a) Lightweight Aggregate (natural and synthetic, expanded shale)
b) LWS Sand (Water absorption =17 %)
c) LWA 19mm Coarse (Water absorption = 20%)
d) Super-absorbent Polymers (SAP) (60-300 mm size)
e) SRA (Shrinkage Reducing Admixture) (propylene glycol type i.e. polyethylene-glycol/ Polyvinyl alcohol)
f) Wood powder.

SCOPE AND OBJECTIVE

Some specific water-soluble chemicals such as Polyvinyl alcohol added during the mixing can reduce water evaporation from and within the set concrete, making it 'self-curing.' The chemicals should have abilities to reduce evaporation from solution and to improve water retention in ordinary Portland cement matrix. The Compressive and tensile strength of self-curing concrete for 7 and 28 days is found out and compared with conventional concrete of similar mix design.

V. PROPERTIES OF MATERIALS:

SUPER-ABSORBENT POLYMER(S A P) FOR INTERNAL CURING:

The common SAPs are added at rate of 0–0.6 wt % of cement. The SAPs are covalently cross-linked. They are Acrylamide/acrylic acid copolymers. One type of SAPs are suspension polymerized, spherical particles with an average particle size of approximately 200 mm; another type of SAP is solution polymerized and then crushed and sieved to particle sizes in the range of 125–250 mm. The size of the swollen SAP particles in the cement pastes and mortars is about three times larger due to pore fluid absorption. The swelling time depends especially on the particle size distribution of the SAP. It is seen that more than 50% swelling occurs within the first 5 min after water addition. The water content in SAP at reduced RH is indicated by the sorption isotherm.

SAPs are a group of polymeric materials that have the ability to absorb a significant amount of liquid from the surroundings and to retain the liquid within their structure without dissolving. SAPs are principally used for absorbing water and aqueous solutions; about 95% of the SAP world production is used as a urine absorber in disposable diapers. SAPs can be produced with water absorption of up to 5000 times their own weight. However, in dilute salt solutions, the absorbency of commercially produced SAPs is around 50 g/g. They can be produced by either solution or suspension polymerization, and the particles may be prepared in different sizes and shapes including spherical particles. The commercially important SAPs are covalently cross-linked polyacrylates and copolymerized polyacrylamides/ polyacrylates. Because of their ionic nature and interconnected structure, they can absorb large quantities of water without dissolving. From a chemical point of view, all the water inside a SAP can essentially be considered as bulk water. SAPs exist in two distinct phase states, collapsed and swollen. The phase transition is a result of a competitive balance between repulsive forces that act to expand the polymer network and attractive forces that act to shrink the network. The macromolecular matrix of a SAP is a polyelectrolyte, i.e., a polymer with ionisable groups that can dissociate in solution, leaving ions of one sign bound to the chain and counter-ions in solution. For this reason, a high concentration of ions exists inside the SAP leading to a water flow into the SAP due to osmosis. Another factor contributing to increase the swelling is water solvation of hydrophilic groups present along the polymer chain. Elastic free energy opposes swelling of the SAP by a retractive force.

SAPs exist in two distinct phase states, collapsed and swollen. The phase transition is a result of a competitive balance between repulsive forces that act to expand the polymer network and attractive forces that act to shrink the network.

VI. MEANS OF PROVIDING WATER FOR SELF CURING CONCRETE USING LIGHT WEIGHT AGGREGATES:

Water/moisture required for internal curing can be supplied by incorporation of saturated-surface dry (SSD) lightweight fine aggregates (LWA).

VII. WATER AVAILABLE FROM LIGHT WEIGHT AGGREGATES FOR SELF CURING:

It is estimated by measuring desorption of the LWA in SSD condition after exposed to a salt solution of potassium nitrate (equilibrium RH of 93%). The total absorption capacity of the LWA can be measured by drying a Saturated Surface Dry (SSD) sample in a dessicator.

VIII. WATER IN LIGHT WEIGHT AGGGREGATES FOR INTERNAL CURING:

About 67% of the water absorbed in the LWA can get transported to self-desiccating paste. Some water remains always in the LWA in the high RH range and it becomes useful when the overall RH humidity in concrete is significantly reduced. The

water retained in LWA in air-dry condition may not be enough to prevent autogenous shrinkage whose magnitude, however, may be reduced significantly. The fine lightweight aggregate, in saturated condition, produce a more uniform distribution of the water needed for curing throughout the microstructure.

The grain size of the LWA used as curing agent should be less in order to minimize the paste–aggregate proximity, i.e. the distance to which the internal curing water could diffuse. The grain size of down to 2–4 mm is found to be beneficial.

POLYVINYL ALCOHOL AS SELF CURING AGENT:

Polyvinyl alcohol is produced commercially from polyvinyl acetate, usually by a continuous process. The acetate groups are hydrolyzed by ester interchange with methanol in the presence of anhydrous sodium methylate or aqueous sodium hydroxide. Polyvinyl alcohol is an odorless and tasteless, translucent, white or cream colored granular powder. Polyvinyl alcohol contains two OH groups. It helps to retain water from concrete. It is soluble in water, slightly soluble in ethanol, but insoluble in other organic solvents. Typically a 5% solution of polyvinyl alcohol exhibits a pH in the range of 5.0 to 6.5. Polyvinyl alcohol has a melting point of 180 to 190°C.

Specific gravity of Fine aggregate:

An Indian standard specification IS: 2386(part III) of 1963 gives various procedures to find specific gravity of aggregate. In this study specific gravity is found by using pychnometer method,

Specific gravity of natural sand is found to be 2.60. Specific gravity of Coarse aggregate is found to be 2.63.

Fineness modulus:

Fineness modulus of natural sand is found to be 2.7

Fineness modulus of Coarse aggregate is found to be 2.8

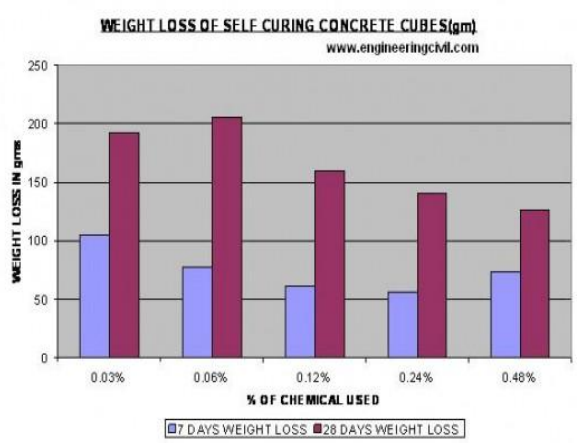
Design and above proportion were found out for M25 grade concrete.

DETERMINATION OF PHYSICAL PROPERTIES OF CONCRETE:

By using varying percentages of Polyvinyl alcohol Concrete cubes were casted and average weight loss was found after 7 and 28 days are shown in table- 1and a graph-1 as under:

Table1: average weight loss in gm.

SR. NO.	% Poly vinyl alcohol by the weight of cement	AVERAGE WEIGHT LOSS(gm)	
		7 DAYS	28DAYS
1	0.03	105.25	192.67
2	0.06	77.5	205.67
3	0.12	61	160
4	0.24	56	140.67
5	0.48	73	126.33

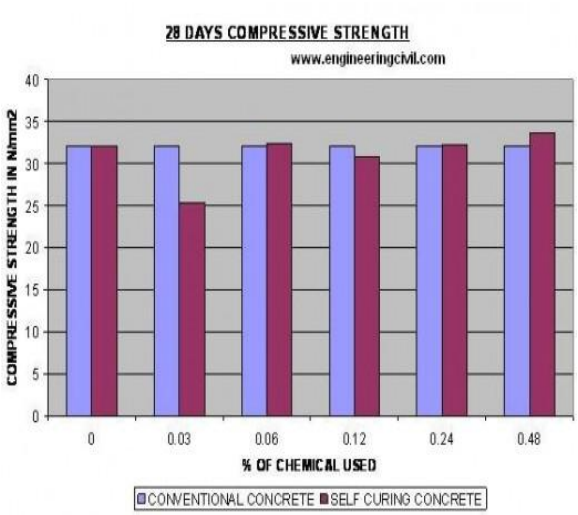


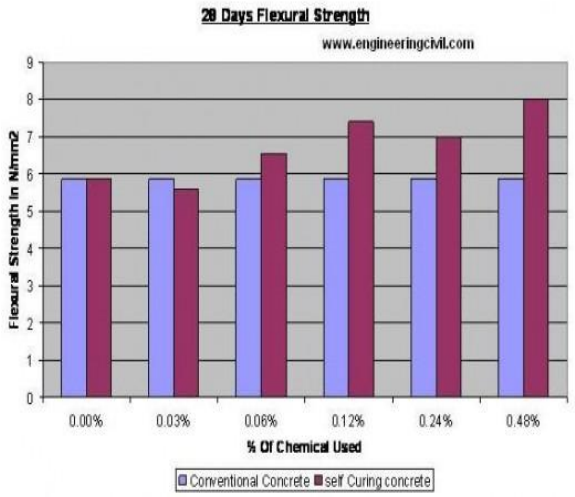
2 DETERMINATION OF MECHANICAL PROPERTIES OF CONCRETE:

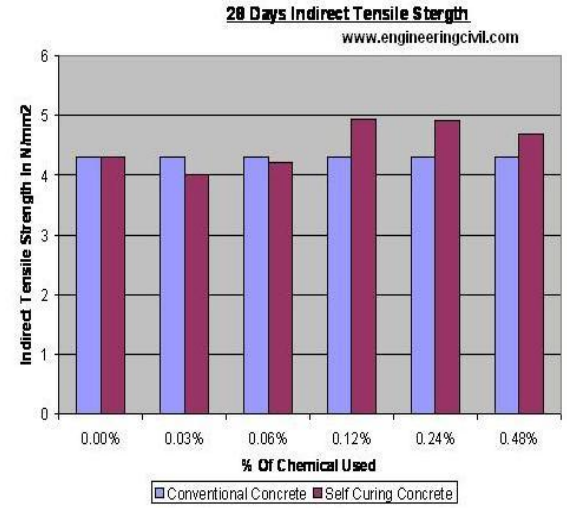
Compressive strength, flexural strength and indirect tensile strength of conventional and self cured concrete are found and results are shown in table:2 and graphical representation of results are shown in Fig.2,3 & 4.

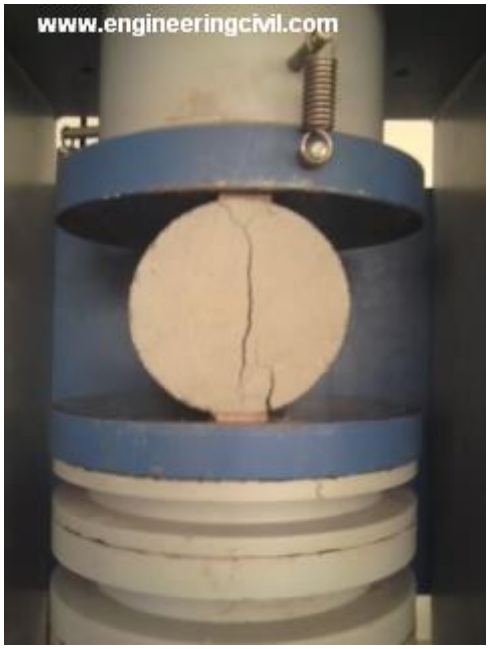
Table 2: Comparative statement

	% Poly vinyl alcohol by the weight of cement	Average Compressive Strength after 28days(N/mm^2)	Average indir. Tensile Strength after 28days(N/mm)	Average Flexural Strength after 28days(N/mm^2)
1	0.00 (Conventional mix)	32.1	4.30	5.856
2	0.03	25.4	4.005	5.6
3	0.06	32.4	4.215	6.54
4	0.12	30.9	4.945	7.4
6	0.24	32.2	4.920	7.0
7	0.48	33.7	4.691	8.0









DURABILITY TEST ON CONCRETE CUBES:

The Conventional concrete cubes as well as self cured cubes (curing period of 28 days) were immersed in salty water. The % of salt used was 10% by weight of water. cubes were cured in salty water for14 days. After 14 days they were tested under compression testing machine. The results found are shown in table:3

Table-3 compressive strength after 14 days immersion in salty water

SR. NO	TYPES OF CUBES	COMPRESSIVE STRENGTH N/mm^2
1	Conventional concrete cubes	28.9
	Self curing concrete cubes	
2	0.03	23.3
3	0.06	30.1
4	o.12	26.7
5	o.24	29.8
6	0.48	30.1

IX. ADVANTAGES OF SELF CURING CONCRETE /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. In low w/c ratio mixes (under 0.43 and increasingly those below 0.40) absorptive lightweight aggregate, replacing some of the sand, provides water that is desorbed into the mortar fraction (paste) to be used as additional curing water. The cement, not hydrated by low amount of mixing water, will have more water available to it.

a. IC provides water to keep the relative humidity (RH) high, keeping self-desiccation from occurring.
b. IC eliminates largely autogenous shrinkage.
c. IC 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.
d. IC can make up for some of the deficiencies of external curing, both human related (critical period when curing is required is the first 12 to 72 hours) and hydration related (because hydration products clog the passageways needed for the fluid curing water to travel to the cement particles thirsting for water). Following factors establish the dynamics of water movement to the unhydrated cement particles:
   i. Thirst for water by the hydrating cement particles is very intense,
   ii. Capillary action of the pores in the concrete is very strong, and
   iii. Water in the properly distributed particles of LWA (fine) is very fluid.

X. CONCRETE DEFICIENCIES THAT SELF CURING CONCRETE CAN ADDRESS:

The benefit from self curing concrete can be expected when

- Cracking of concrete provides passageways resulting in deterioration of reinforcing steel,
- low early-age strength is a problem,
- permeability or durability must be improved,
- rheology of concrete mixture, modulus of elasticity of the finished product or durability of high fly-ash concretes are considerations.
- Need for: reduced construction time, quicker turnaround time in precast plants, lower maintenance cost, greater performance and predictability.

XI. IMPROVEMENTS OF CONCRETE DUE TO INTERNAL CURING:

- Reduces autogenous cracking,
- largely eliminates autogenous shrinkage,
- Reduces permeability,
- Protects reinforcing steel,
- Increases mortar strength,
- Increases early age strength sufficient to withstand strain,
- Provides greater durability,
- Higher early age (say 3 day) flexural strength
- Higher early age (say 3 day) compressive strength,
- Lower turnaround time,
- Improved rheology
- Greater utilization of cement,
- Lower maintenance,
- use of higher levels of fly ash,
- higher modulus of elasticity, or
- through mixture designs, lower modulus
- sharper edges,
- greater curing predictability,
- higher performance,
- improves contact zone,
- does not adversely affect finishability,
- does not adversely affect pumpability,
- reduces effect of insufficient external curing

XII. CONCLUDING REMARKS:

The following could be concluded from the results obtained in this study :

i) Water retention for the concrete mixes incorporating self curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time.
ii) Self-curing concrete resulted in better hydration with time under drying condition compared to conventional concrete.
iii) Performance of the self-curing agent will be affected by the mix proportions mainly the cement content and the w/c ratio.
iv) Use of Polyvinyl alcohol (0.48% by the weight of cement) as self curing agent Provides higher compressive, tensile as well as flexural strength than the Strengths of conventional mix.
v) Increase in the Percentage of polyvinyl alcohol results in the reduction of weight loss.
vi) Durability of self-curing concrete to sulphate salts and chloride induced corrosion is needed to be evaluated.
vii) In the study cubes were casted and kept for curing in room temperature about 250-300c.practical feasibility of self cured member is need to be checked in hot region.

REFERENCES:

[1] Bentz, D.P., "*Capillary Porosity Depercolation/Repercolation in Hydrating Cement Pastes via Low Temperature Calorimetry Measurements and CEMHYD3D Modeling*," Journal of the American Ceramic Society, 89 (8), 2606-2611, 2006.
[2] Bentz, D.P., "*Influence of Curing Conditions on Water Loss and Hydration in Cement Pastes with and without Fly Ash Substitution,"* NISTIR 6886, U.S. Dept. Commerce, July 2002.
[3] Bentz, D.P., and Snyder, K.A., *"Protected Paste Volume in Concrete: Extension to Internal Curing Using Saturated Lightweight Fine Aggregates,"* Cement and Concrete Research. 29, 1863-1867, 1999.

[4] Bentz, D.P., and Stutzman, P.E., "*Curing, Hydration, and Microstructure of Cement Paste,"* ACI Materials Journal, 103 (5), 348-356, 2006.

[5] Bentz, D.P., Garboczi, E.J., and Snyder, K.A., "*A Hard Core/Soft Shell Micro structural Model for Studying Percolation and Transport in Three–Dimensional Composite Media,"* NISTIR 6265, U.S. Department of Commerce, 1999.

[6] Bentz, D.P., Halleck, P.M., Grader, A.S., and Roberts, J.W., "*Direct Observation of Water Movement during Internal Curing Using X-ray Microtomography*," Concrete International, 28 (10), 39-45, 2006.

[7] "*SELF-CURING CONCRETE: WATER RETENTION, HYDRATION AND MOISTURE TRANSPORT*" A.S. El-Dieb Department of Structural Engineering, Faculty of Engineering, Ain Shams University, 1 El-Sarayat St., Abbasia 11517, Cairo, Egypt

[8] "*SELF-CURING CONCRETE*", By Tarun R. Naik and Fethullah Canpolat Report No. CBU-2006-11 REP-610 April 2006 A CBU Report Department of Civil Engineering and Mechanics College of Engineering and Applied Science

[9] "*THE UNIVERSITY OF WISCONSIN-MILWAUKEE MIXTURE PROPERTIES FOR INTERNAL CURING*" By: Dale P. Bentz, Pietro Lura, John W. Roberts INTERNATIONAL CONCRETE/FEB2005

[10] "*INVESTIGATIONS AND STUDY ON THE EFFECT OF AR GLASS POLYMER FIBRES IN SELF-COMPACTING SELF-CURING CONCRETE*." S. U. Kannan, Selvamony C., M. S. Ravikumar and S. Basil Gnanappa Sathyabama University, Chennai, India C.S.I Engineering College, Nagercoil, India

[11] "*INVESTIGATIONS ON SELF-COMPACTED SELF-CURING CONCRETE USING LIMESTONE POWDER AND CLINKERS*." C. Selvamony, M. S. Ravikumar, S. U. Kannan and S. Basil Gnanappa. Sun College of Engineering and Technology, Sathyabama University, Chennai India.

[12] "*BEHAVIOUR OF SELF COMPACTED SELF CURING KILN ASH CONCRETE WITH VARIOUS ADMIXTURES*" M. S. Ravikumar, Selvamony C., S. U. Kannan and S. Basil, India

[13] Dhir, R. K., Hewlett, P. C., Lota, J. S., and Dyer, T. D.,*An Investigation into the feasibility of formulating 'self-cure' concrete,? Materials and Structures/Materiaux et Constructions*, Vol. 27, No. 174, 1994, pp. 606-615.