Self-Curing Concrete - Introduction

[1]Muddassir Bora, [2]Mausam Vohra, [3]Mohammed Sakil Patel, [4]Dhruv Vyas

[1,2,3]Students, [4]Professor
Civil Department,
Sardar Patel College of Engineering, Anand,India

Abstract—**The strength and durability of concrete depends on the curing of concrete. The ACI-308 Code states that "internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing Water." Conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e., curing is taken to happen 'from the outside to inside'. In contrast, 'internal curing' is allowing for curing 'from the inside to outside' through the internal reservoirs (in the form of saturated lightweight fine aggregates, superabsorbent polymers, or saturated wood fibres) Created. 'Internal curing' is often also referred as 'Self–curing.' Any negligence in in curing will interfere in the strength and durability of concrete. Shrinkage reducing agents and lightweight aggregates such as Polyethylene-glycol and Leca, Silica fume and stone chips are used respectively to achieve effective curing results.**

IndexTerms—**Self-curing concrete; Internal curing; Leca; Polyethylene-glycol; Silica fume.**

I. INTRODUCTION

Curing plays a major role in the development of concrete properties during construction. Curing is frequently used to describe the process by which hydraulic cement concrete matures and develops hardened properties over time as a result of the continued hydration of the cement in the presence of sufficient water (ACI, 2008). The role of curing is to reduce water evaporation from the concrete and maintain satisfactory moisture content, especially during early ages, for continuation of the hydration process that is necessary for the development of cement microstructure. This will lead to a better quality cement paste and concrete and will help to achieve the desired properties. However, good curing is not practical in many cases and some researchers have questioned whether it is possible to prepare self-curing concrete (Bentz et al., 2005; Dhir et al., 1994, 1995, 1996; Mather, 2001; Reinhardt and Weber, 1998). It was found that the benefit of using self-curing agents is to reduce water evaporation from concrete, thus increasing its water retention capacity compared with that of conventional concrete and that water-soluble polymers might have this potential.

Construction industry use lot of water in the name of curing. The days are not so far that all the construction industry has to switch over to an alternative curing system, not only to save water for the sustainable development of the environment but also to promote indoor and outdoor construction activities even in remote areas where there is scarcity of water.

Curing is the process of controlling the rate and extent of moistureloss from concrete during cement hydration. It may be either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time – days, and even weeks rather than hours – curing must be undertaken for a reasonable period of time. If the concrete is to achieve its potential strength and durability Curing may also encompass the control of temperature since this affects the rate at which cement hydrates.

The curing period may depend on the properties required of the concrete, the purpose for which it is to be used, and the ambient conditions, i.e. the temperature and relative humidity of the surrounding atmosphere. Curing is designed primarily to keep the concrete moist, by preventing the loss of moisture from the concrete during the period in which it is gaining strength. Curing may be applied in a number of ways and the most appropriate means of curing may be dictated by the site or the construction method. Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. The need for adequate curing of concrete cannot be overemphasized. Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing and deicers.

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. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. 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.

II. Need for 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, due to depercolation 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. This situation is intensified in HPC (compared to conventional concrete) due to its generally higher cement content, reduced water/cement (w/c) ratio and the pozzolanic mineral admixtures (fly ash, silica fume). The empty pores created during self-desiccation induce shrinkage stresses and also influence the kinetics of cement hydration process, limiting the final degree of hydration. The strength achieved by IC could be more than that possible under saturated curing conditions. Often specially in HPC, it is not easily possible to provide curing water from the top surface at the rate required to satisfy the ongoing chemical shrinkage, due to the extremely low permeability's often achieved.

III. Methods of Self-Curing

Currently, the method uses poly-ethylene glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention

IV. Mechanism of Internal curing

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (free energy) between the vapours 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.

V. Potential Materials for Internal Curing

The following materials can provide internal water reservoirs:

- Aggregate
- Fine Aggregate
- OPC Cement
- Polyethylene glycol PEG

VI. Improvements to Concrete due to Internal Curing

- Reduces autogenously cracking,
- largely eliminates autogenously 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 finish ability,

- does not adversely affect pump ability,
- Reduces effect of insufficient external curing.

VII. Conclusion

The internal curing (IC) by the addition of saturated lightweight fine aggregates is an effective means of drastically reducing autogenous shrinkage. Since autogenous shrinkage is a main contributor to early-age cracking, it is expected that IC would also reduce such cracking. An additional benefit of IC beyond autogenous shrinkage reduction is increase in compressive strength. As internal curing maintains saturated conditions within the hydrating cement paste, the magnitude of internal self-desiccation stress is reduced and long term hydration is increased. IC is particularly effective for the high performance concretes containing silica fume and GGBS. In cement mortar containing a Type F fly ash, the fly ash functions mainly as a diluent at early ages, and higher and coarser porosity at early ages result in less autogenous shrinkage.

IC is useful when 'performance specifications' are important than 'prescriptive specifications' for concrete. Prime applications of IC could be: concrete pavements. precast concrete operations, parking structures, bridges, HPC projects, and architectural concretes. Concrete, in the 21st century, needs to be more controlled by the choice of ingredients rather than by the uncertainties of construction practices and the weather. Instead of curing through external applications of water, concrete quality will be engineered through the incorporation of water absorbed within the internal curing agent.

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 Microstructural 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] Bentz, D.P., Lura, P., and Roberts, J.W., "Mixture Proportioning for Internal Curing," Concrete International, 27 (2), 35-40, 2005.

[8] Bilek, B et al, "The possibility of self-curing concrete Proc Name Innovations and developments in concrete materials and construction." Proc. Intl Conf. University of Dundee, UK. 9-11 September 2002.

[9] Cusson, D., and Hoogeveen, T., "Internally-Cured High- Performance Concrete under Restrained Shrinkage and Creep," CONCREEP 7 Workshop on Creep, Shrinkage and Durability of Concrete and Concrete Structures, Nantes, France, Sept. 12-14, 2005, pp. 579-584.

[10] De Jesus Cano Barrita, F.; Bremner, T.W.; Balcom, B.J., "Use of magnetic resonance imaging to study internal moist curing in concrete containing saturated lightweight aggregate," High-performance structural lightweight concrete. ACI fall convention, Arizona, October 30, 2002. ACI SP 218.