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EXPERIMENTAL STUDY ON INTERNAL CURING OF HIGH STRENGTH CONCRETE

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ABSTRACT

Self-curing concrete is provided to absorb water from atmosphere and then release to concrete to achieve better hydration of cement which solves the problem of lowered cement hydration because of improper curing, and thus unsatisfactory properties of concrete. The present investigation involves the use of self-curing agent, Solid paraffin wax (SPW) melted at 70ºC of dosages ranging between 0.1 to 2% by weight of cement added to water along with Super-Plasticizer (Master Rheo-build). Comparative studies were carried out for Water retentivity, Compressive strength, Split Tensile strength and Flexural Strength tests after 28 days for conventional cured and self-cured concrete.

KEYWORDS: Self-curing concrete, Solid Paraffin wax, super plasticizer

INTRODUCTION

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.

There are several methods of curing: Ponding or spraying, covering of wet hessian, reducing the rate of evaporation of water from concrete surface by covering with a relatively impermeable membrane, delaying the removal of formwork can also be used to retain some water, steam curing.

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 fibers) Created. 'Internal curing' is often also referred as 'Self–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.

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According to R.T.Y Liang and R.K Sun, 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.

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. 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).

EXPERIMENTAL PROGRAM

Materials used :

Cement

OPC 43 Grade was used for the complete study. The Specific gravity test conducted on cement gave a value of about 3.15.

Fine and Coarse Aggregate

River sand with a fineness modulus of 3.91 was used as fine aggregate. Coarse aggregate comprised a maximum size of 20 mm. The fine and coarse aggregate specific gravities are 2.67 and 2.84 respectively (IS 2720(Part I – Sec I):1980) and water absorption of 2.0 and 0.42% respectively.

Solid Paraffin Wax

Paraffin wax is colourless or white, translucent, hard wax consisting of a mixture of solid straight-chain hydrocarbons ranging in melting point from about 48° to 66° C (120° to 150° F). Paraffin wax is obtained from petroleum by de-waxing light lubricating oil stocks. It is used in candles, wax paper, polishes, cosmetics, and electrical insulators. It assists in extracting perfumes from flowers, forms a base for medical ointments, and supplies a waterproof coating for wood. In wood and paper matches, it helps to ignite the matchstick by supplying an easily vaporized hydrocarbon fuel.

Fig.1 Solid paraffin wax

Super-Plasticizer

Master Rheo-build is a super plasticising admixture. It is based on Sulphonated Napthalene polymers and supplied as a brown liquid instantly dispersible in water.It has been specially formulated to give highwater reductions upto 25% without loss of workability or to produce high quality concrete of reduced permeability

Mix Proportion and test specimens

Grade of concrete used in this study is M50 with a water-cement ratio 0.35 and the mix ratio is 1:1.472:3.043:0.35.

A. Casting and Curing

A total of 48 specimens were cast with cubes, cylinders and prisms as 24, 16 and 8 respectively. Solid paraffin wax melted at 70ºC was added to concrete. Specimens were cured for about 7 and 28 days duly.

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B. Test Procedure

Compressive strength

Cubical specimens of size 150mm were cast and cube compressive strength was determined as per IS standards.

Split Tensile strength

The tensile strength of the resultant mix is judged in terms of split tensile strength using cylindrical specimens of size 150 mm diameter x 300 mm height. Two samples of each mix were cast and compared.

Flexural Strength

In this test, the beam specimens 150x150x500 mm were tested in flexure at 28 days to determine modulus of rupture and load deflection behavior

Water Retentivity Test

Water Retentivity is the ability of the substance to retain water. To perform the water retentivity test, the cubes were weighed for every 3 days from the date of casting. Weight loss for the specimens in indoor curing, and weight gain for the conventional curing are noted and their behaviour is plotted in graph against number of days of curing.

RESULTS AND DISCUSSION

A. Compressive strength

A comparison between the Average Compressive strength and % of Solid paraffin wax added to concrete for 7 and 28 days were done. The average compressive strength value of Internally cured concrete had shown a decline at 0.1, 1 and 2% ratios when compared to conventional concrete. But 1% SPW addition had shown satisfactory result than the other two.

Table 1. Compressive strength of conventional concrete

Type of concrete	**Nature**	**Average Compressive strength(MPa)**	
		7 days	**28 days**
Conventional Concrete	Water Curing	39.67	61.50
	Air Curing	33.94	54.35

Table 2. Compressive strength of internally cured concrete

Type of concrete	**Nature**	**Average Compressive strength(MPa)**	
		7 days	**28 days**
Internally cured Concrete	0.1%	30.41	49.54
	1%	36.51	59.75
	2%	32.15	52.50

Table 3. % Difference in compressive strength between conventional and internally cured concrete

Average compressive strength	Compressive strength (MPa)			
	Conventional concrete	Internally Cured concrete		
		0.1%	1%	2%
7 days	39.67	30.41	36.51	32.15
Difference in %		-23.34	-7.9	-18.95
28 days	61.5	49.54	59.75	52.50
Difference in %		-19.44	-2.84	-14.63

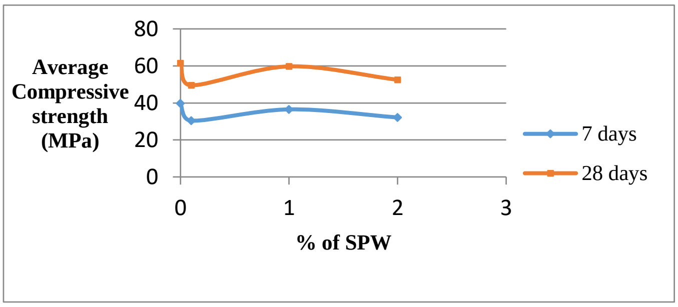

Fig.2 Compressive strength Vs % of SPW

B. Split Tensile strength

A comparison between the Average Split tensile strength and % of Solid paraffin wax added to concrete for 7 and 28 days were done. The average Split tensile strength value of internally cured concrete had shown a decline at 0.1, 1 and 2% ratios when compared to conventional concrete. But 1% SPW addition had shown satisfactory result than the other two.

Table 4. Split tensile strength of conventional concrete

Type of concrete	Nature	Average Split Tensile strength(MPa)	
		7 days	28 days
Conventional Concrete	Water Curing	2.155	2.98
	Air Curing	1.765	2.45

Table 5. Split tensile strength of internally cured concrete

Type of concrete	**Nature**	**Average Split Tensile strength(MPa)**	
		7 days	**28 days**
Internally cured Concrete	0.1%	1.905	2.67
	1%	2.010	2.89
	2%	1.66	2.35

Table 6. % difference in split tensile strength between conventional and internally cured concrete

Average Split tensile strength	Split Tensile strength (MPa)			
	Conventional concrete	Internally Cured concrete		
		0.1%	1%	2%
7 days	2.155	1.905	2.01	1.66
Difference in %		-11.60	-6.7	-22.96
28 days	2.98	2.67	2.89	2.35
Difference in %		-10.4	-3.02	-21.14

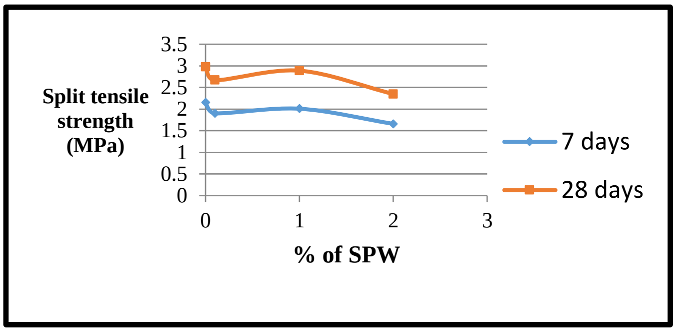

Figure 3. Split tensile strength vs % of SPW

C. **Flexural strength**

A comparison between the Flexural strength and % of Solid paraffin wax added to concrete for 7 and 28 days were done. The flexural strength value of Internally cured concrete had shown a decline at 0.1, 1 and 2% ratios when compared to conventional concrete. But 1% SPW addition had shown satisfactory result than the other two.

Table 7. Split tensile strength of internally cured concrete

Mix	% of SPW	'a' mm	Max Load	Flexural Strength N/mm²
Conventional Concrete	0	205	1700	6.83
Internally cured concrete	0.1	195	1600	6.45
	1	210	1650	6.63
	2	205	1550	6.23

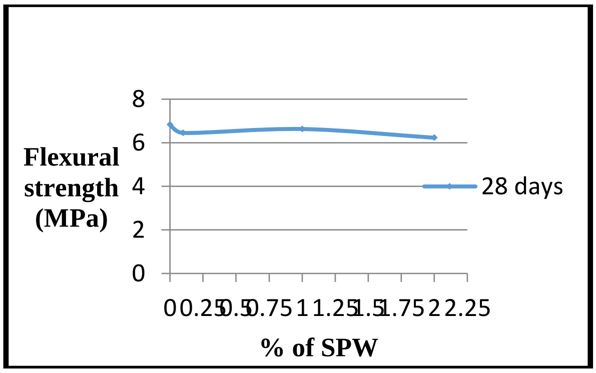

Fig.4. Split tensile strength vs % of SPW

D. **Water Retentivity Test**

Weight loss in 2% SPW addition had shown lesser value than the other ratios viz., 0.1 and 1%.

Nomenclature of Mix	Difference in %	
	7 days	28 days
C moisture	1.64	2.12
C air	-1.23	-1.80
S 0.1 %	-1.18	-1.71
S 1%	-0.92	-1.55
S 2%	-0.75	-1.27

CONCLUSION

The objective of this study was to check the enhancement of internally cured concrete with the addition of SPW and Super Plasticizer, and it had shown satisfactory results. Those were listed below:

- The Compression test result had shown a higher value in case of 1% when compared to 0.1 and 2% SPW addition.
- The Split tensile test result had shown a higher value in case of 1% when compared to 0.1 and 2% SPW addition.
- The Flexural test result had shown a higher value in case of 1% when compared to 0.1 and 2% SPW addition.
- Water retentivity test had shown that 2% addition of SPW would result in lesser weight loss when compared with the other two SPW dosages.
- The fibre reinforced to SPW added concrete would enhance the Split tensile strength

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