Comparison Of Compressive Strength Of Medium Strength Self Compacted Concrete By Different Curing Techniques

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Abstract: In this paper variation in compressive strength of medium strength, self-compacted concrete with 3 different curing techniques is discussed. Initially several trials were carried out for mix design of medium strength self-compacting concrete. Once the mix design was achieved, three batches of concrete cubes were cast as per ASTM standard. Water cement ratio and admixture dose were kept constant as required by selected Mix Design. Slump Test was carried out on each batch in order to ascertain concrete flow for self-compacting concrete. First batch was cured in a temperature controlled curing tank in the laboratory. The second batch was cured by the application of an external curing compound under prevailing site conditions. The 3rd batch was cured with internal curing agent. From each batch, 3 cubes were tested for compressive strength at 3-days age, at 7 days age and 28 days age of concrete and average values were taken. Results were analyzed and graphs were drawn.

It was noted that 28-days compressive strength of cubes cured by applying curing compound was 91 % of the compressive strength of cubes cured in water tank in the laboratory (i.e., 09 % less). Similarly compressive strength of cubes cured by

Internal curing compound was 95 % of the compressive strength of cubes cured in the laboratory (i.e., 05% less). So it was concluded that in areas with shortage of water, curing compounds can be effectively used with improved strength and sustainability of self-compacted concrete.

Keywords: Self compacted concrete, dose of Superplasticizer, Water/Cement ratio, curing compound, internal curing, and compressive strength.

I.INTRODUCTION

Self-Compacted Concrete (SCC) is highly workable concrete with high strength and high performance that can flow under its own weight through restricted sections without segregation and bleeding. SCC is achieved by reducing the volume ratio of aggregate to cementitious material, increasing the paste volume and using various viscosity enhancing admixtures and superplasticizers. They are called High Range Water Reducers (HRWR) in American literature. It is the use of superplasticizer which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 MPa or more. Building elements made of high strength concrete are usually densely reinforced. The lesser distance between reinforcing bars may lead to defects in concrete. If high strength concrete is self-compacting, the production of densely reinforced building elements from high strength concrete with high homogeneity would be an easy work (Ma, et al. 2003).

The behaviour of the design concrete mix is significantly affected by variation in humidity and temperature both in fresh and hardened state, **(**Kumbhar, P.D and Murnal, P., Nov. 2011). During the concrete curing humidity and temperature

plays an important role to achieve the designed strength of concrete.

Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration.

This can be achieved either by:

Continuously wetting the exposed surface thereby preventing the loss of moisture from it OR ponding or spraying the surface with water OR leaving formwork in place OR covering the concrete with an impermeable membrane after the formwork has been removed OR by the application of a suitable chemical curing agent (wax etc.) or using chemicals for internal curing OR by a combination of such methods.

The strength of concrete is affected by a number of factors, one of which is the length of time for which it is kept moist, i.e. cured, another being the method by which it is being cured.

Inadequate or insufficient curing is one of main factors contributing to weak, powdery surfaces with low abrasion resistance.

In the present paper we have chosen three different methods of curing:

1. Traditional immersion or ponding method
2. Application of Wax based external coating
3. Using chemical for internal curing leading to self-compacted, self-curing concrete.

Ponding or immersion (M3I): This is the most common and inexpensive method of curing flat surfaces such as floor slabs, flat roofs, pavements and other horizontal surfaces. A dike around the edge of the slab, which may be sub-divided into smaller dikes, is erected and water is filled to create a shallow pond. Care must be taken to ensure that the water in the pond does not dry up, as it may lead to an alternate drying and wetting condition. The concrete surface remains continuously moist. This prevents the moisture from the body of concrete from evaporating and contributes to the strength gain of concrete

Curing compounds (M3C) - Curing compounds are wax, acrylic and water based liquids which are sprayed over the freshly finished concrete to form an impermeable membrane that minimizes the loss of moisture from the concrete. When used to cure concrete the timing of the application is critical for maximum effectiveness. They must be applied when the free water on the surface has evaporated and there is no water sheen on the surface visible. Too early application dilutes the membrane, where as too late application results in being absorbed into the concrete.

Curing compounds may also prevent the bond between the hardened and the freshly placed concrete overlay. For example Curing compounds should not be applied to two lift pavement construction. Similarly, curing compounds should not be applied to concrete surface which will be receiving plasters, decorative & protective paints, etc, as it affects the adhesion.

Internal OR Self-Curing (M3A) - 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.'

II. MATERIALS & TEST METHOD

Materials used in developing cement slurry are having following properties:

- **Cement:** Ordinary Portland cement of 53 grade (Sanghi brand) with Specific Gravity 3.15, available in local market.

Table 1: Properties of cement

PROPERTY	VALUE	IS CODE 112 - 1989
Specific Gravity	3.15	3.10-3.15
Consistency	28%	30-35
Initial setting time	35min	30min minimum
Final setting time	178min	600min maximum
Compressive strength at 7 days N/mm^2	38.49 N/mm^2	43 N/mm^2

Compressive strength at 28 days N/mm^2	52.31 N/mm^2	53 N/mm^2

- **Water**: Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water was used for mixing.
- **Fly Ash:** Class C Fly ash was used with Specific Gravity 2.13, VanakBori Thermal Station in Kheda District, Gujarat, India.

Table 2: Properties of Flyash

Constituents	Weight by %
Loss on ignition	4.17
Silica (SiO2)	69.40
Iron Oxide (Fe2O3)	3.44
Alumina (Al2O3)	28.20
Calcium Oxide (CaO)	2.23
Magnesium Oxide (MgO)	1.45
Total Sulphur (SO3)	0.165
Insoluble residue	-
Sodium Oxide (Na2O)	0.58
Potassium Oxide (K2O)	1.26

- **Aggregates (FA & CA)**

Sand, ≤ 4.75mm: Specific gravity 2.55 & Fineness Modulus 2.87, Zone II, from Bodeli, Vadodara,Gujarat, India.

Table 3: Properties of sand

Particulars	Value of Sand
Source	Bodeli, Gujarat
Zone	Zone II
Specific Gravity	2.55
Fineness Modulus	2.87
Bulk Density	1776.29 kg/m^3
Colour	Yellowish White

Grit, 4.75 to 12.5mm: Specific gravity 2.75 & Fineness Modulus 5.76, Sevaliya, Kheda District, Gujarat, India.

Table 4: Properties of Grit

Particulars	Grit
Source	Sevalia, Gujarat
Specific Gravity	2.75
Fineness Modulus	5.76
Bulk Density	1764.14 kg/m^3
Colour	Greyish Black

- **Superplasticizers (SP):** Polycarboxylates ether condensate (PCE) based superplasticizers were used Brand name Glanium B276 Suretec. Dosages of superplasticizers was fixed 1.1% of cementitious material. Marsh cone method was used to optimize the dosage of SP.

Table 5: BASF Glanium B276 SURETEC

Aspect	Light brown liquid
Relative Density	1.10 ± 0.02 at 25° C
pH	≥6
Chloride ion content	<0.2%

Figure 1, SP B276

- **Curing Compound:** I was procured from FAIR MATE chemical Pvt. Ltd. With the brand name FAIRCURE WX WHITE (wax based).

Figure 2, Wax Based Curing Compound

- **Polyethylene Glycols, PEG - 600:** It is a liquid chemical with specific gravity 1.12 and transparent color. Dosages of PEG's was decided with reference to relevant literature review and fixed as 0.5% of cementitious material. The product was procured from fine-chem Ltd, Mumbai.

Figure 3, PEG 600 Self Curing

Mix proportion of SCC

There is no standard method for SCC mix design and many academic institutions, admixture, ready-mixed, pre cast and contracting companies have developed their own mix proportioning methods. Our design was based on EFNARC specifications. All concrete batches were prepared in rotating drum mixture. First, the aggregates are introduced and then one-half of the mixing water is added and rotated for approximate two minutes. Next, the cement and fly ash were introduced with HRWR admixture already mixed in the remaining water. Most manufactures recommend at least 5 minutes mixing upon final introduction of Admixture.

Table 6: Selected Mix Design for M30 Grade

Cement KG	Flyash KG	F.A KG	C.A KG	Water Lit	SP	W/P Ratio
375	175	785	735	214.5	1.1%	1.00%

III. RESULTS AND DISCUSSION:

Tests on fresh concrete were performed to study the workability of SCC. The tests conducted are listed below:

- Slump Flow Test
- T50 Test
- V-Funnel
- L-Box Test

Table 7: Acceptance criteria for SCC

Method	Unit	Typical range		Result
		min	max	
Slump flow	mm	650	800	670
T50	sec	2	5	3.8
V-funnel	sec	6	12	10.8
L-Box	(h_2/h_1)	0.8	1.0	0.83

Table 8: Identifications used for Curing Method:

M3I	Immersion
M3C	Curing Compound
M3A	PEG 600

Compressive Strength Result for 3, 7 & 28 day.

150 mm × 150 mm × 150 mm concrete cubes are cast. Specimens with ordinary Portland cement (OPC) replaced with fly ash. The specimens are removed from the mould and subjected to curing for up to 28 days. After curing, the specimens are tested for compressive strength using a calibrated compression testing machine of 200 ton capacities

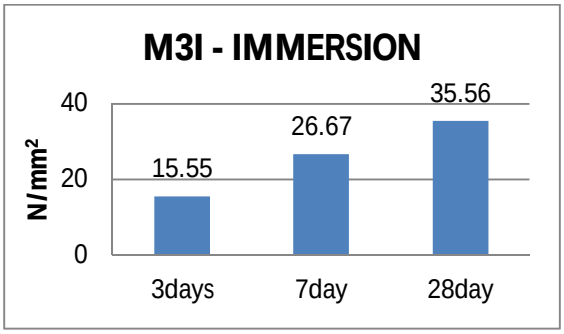
Compressive strength= P/A

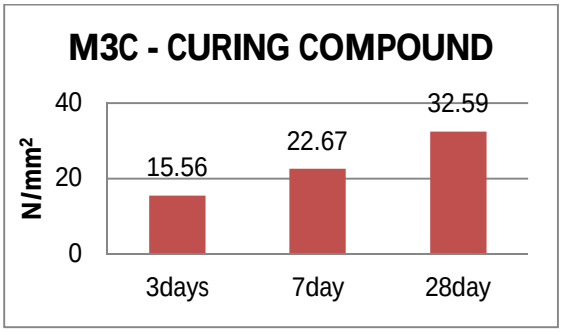
Where, P = failure load in N

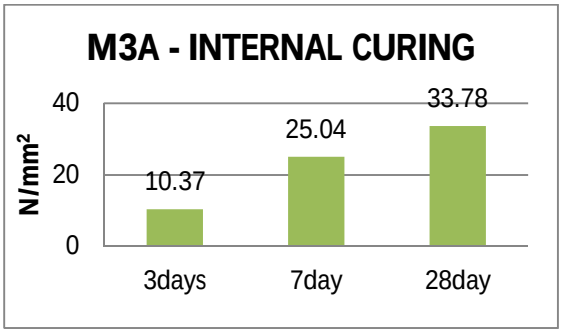
A= cross sectional area in mm^2

Table 9: Test result on hardened concrete

SAMPLE	Compressive strength N/mm^2		
	3days	7days	28days
M3I	15.55	26.67	35.56
M3C	15.56	22.67	32.59
M3A	10.37	25.04	33.78







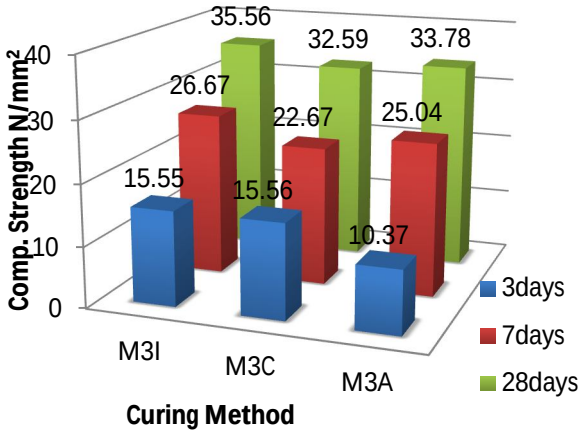
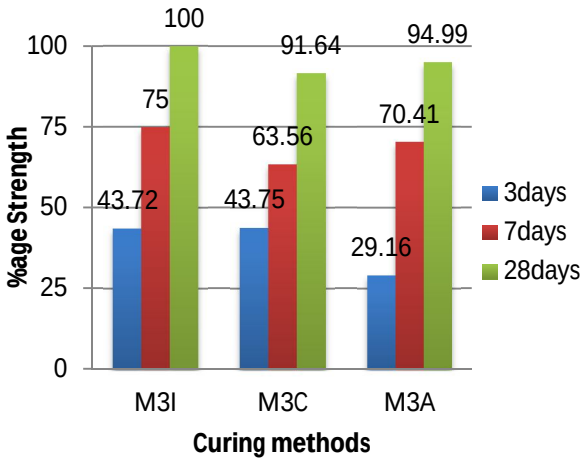


Table 10: Strength Change by %age

SAMPLE	Compressive strength increase by %		
	3days	7days	28days
M3I	43.72	75.00	100
M3C	43.75	63.56	91.64
M3A	29.16	70.41	94.99



IV. CONCLUSION:

(a) Immersion method seems to be the best method for curing giving maximum strength.

(b) External curing with curing compound method gives @9% less compressive strength at 28 days than immersion curing. While internal curing with Polyethelyne Glycol gives only @5% lesser compressive strength than immersion curing.

(c) In case of internal curing the initial strength gain at early age is much lesser (@33%) than immersion curing, however at later age the difference is not much.

(d) In areas with shortage of water, sustainability of water can be achieved by using suitable chemical compounds for curing of concrete.
(e) Compressive strength can also be achieved by using chemical compounds for curing.

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