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# Effect of self curing chemicals in self compacting mortars

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## HIGHLIGHTS

- Development of self compacting mortars using self curing chemicals to enhance the performance of rehabilitation works.
- Arriving suitable self curing chemicals to improve the water retention capacity of mortars for better hydration.
- Optimizing the dosage of various self curing chemicals to obtain better performance.
- Acid Durability Loss Factor-To study the influence of acid attack on concrete specimens.

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## ABSTRACT

Aging of infrastructure necessitates the need for repair and rehabilitation of structures. In this backdrop, self compacting mortar (SCM) is preferred for repair purposes especially in reinforced concrete structures. Due to many different reasons curing is not properly done rendering the repair useless. Self curing in mortars can achieve this by the addition of curing chemicals. Polyethylene Glycol, Liquid Paraffin Wax etc can be very good alternatives to increase the performance of self compacting mortars. These chemicals internally cure the mortars leading to improved hydration and C–S–H gel formation. In the present work, two self compacting mortars 1:1 with $w/c = 0.34$ and 1:3 with $w/c = 0.5$ are investigated with two self curing agents (Polyethylene Glycol 4000 and 200). A comparison was made considering three curing conditions namely wet curing, self-curing and no curing. Different dosages, i.e. 0%, 0.1%, 0.5% and 1.0% mass of PEGs were attempted with the above two curing agents. Mini-slump flow and V funnel tests were done to confirm flow properties required as per the specifications. Water retention, compressive strength, sorptivity and acid durability tests were carried out on SCM specimens. A unified factor viz. Acid Durability Loss Factor is introduced to study the influence of acid in terms of loss of strength, stability and weight loss. This factor accommodates both strength and durability performance. It was concluded from the study that the use of self curing agents in self compacting mortars in optimum dosages benefited self compacting mortars in achieving better strength and durability performance.


## 1. Introduction

Aging of infrastructure facilities necessitates repair and rehabilitation of major structures. In all such cases, self compacting mortars have a key role to play compared to normal mortars [1]. In self compacting mortars, supplementary cementitious materials like fly ash, Ground Granulated Blast Furnace Slag (GGBS), lime powder are incorporated to improve the rheological properties. This enhances the particle distribution which indirectly reduces the paste volume [2,3]. Further, use of high range water reducing admixtures (HRWR) decreases the water/powder ratio, while the high powder content improves the self compacting concrete (SCC) mixture proportioning [4].

Along with compaction, curing plays a predominant role in achieving better strength, durability, water tightness, abrasion resistance, volume stability and resistance to freezing and thawing. Curing is a major factor which is important for the hydration process to continue particularly in the initial ages. However, adequate curing is not always possible by conventional curing techniques and it is recommended to make the embedded water available for curing in order to overcome this problem [5]. The embedded water for curing can be provided using light weight aggregate, super absorbent polymers and hydrophilic materials [6,7]. Amongst many of the curing methods available, use of hydrophilic materials (self curing compounds) in mortars serves as an effective curing method. These polymers added in the mix mainly form

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hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure and thereby, reduce the rate of evaporation from the concrete/mortar surface. Thus, better hydration can be achieved with addition of curing compounds like Polyethylene Glycol (PEG), super absorbent polymers (SAPs), Liquid Paraffin Wax (LPW) etc. The use of self curing technique in self compacting mortars hence provides considerable advantage in repair and rehabilitation of structures.

Dhir et al. [8,9], studied the feasibility of self curing concrete using Poly Ethylene Glycol with different molecular weights. It was concluded from their study that addition of hydrophilic chemicals in water during mixing water to concrete reduces water evaporation, as, the concrete is exposed to air-drying. Liang et al. [10] carried out investigations on internal curing of concrete using combinations of Polyethylene Glycol and paraffin wax. Wen-Chen Jau [11] reported the use of Poly acrylic acid and polyvalent alcohol as self curing agents and their optimum dosages in concrete. Dieb [12,13] evaluated the use of water-soluble polymeric glycol as self-curing agent and further compared water retention and hydration of concrete containing self-curing agents to conventional concrete.

## 2. Research significance

Advanced repair techniques like shotcrete and guniting for repair and rehabilitation works inevitably necessitates use of high performance materials as self compacting mortars (SCM's). However, performance of these materials largely depends on curing. It is very much important to properly cure the mortars particularly in the initial ages. Use of self curing agents in SCM's/SCC's can come to the rescue where curing is either neglected/not properly attended to. The main objective of the current study is to identify a suitable self curing compound with optimum dosage for self compacting mortars. It is also aimed to investigate the strength and durability characteristics to validate the utility in field.

## 3. Experimental program

In the present study, an experimental work was carried out to establish the suitability of a curing compound and its dosage in different types of SCMs. In this study, two SCM mixes i.e. Mix-A (1:1 with *w/c* = 0.34) and Mix-B (1:3 with *w/c* = 0.50), two types of hydrophilic compounds (PEG 200 & PEG 4000), four dosages of hydrophilic compounds (0%, 0.1%, 0.5% and 1.0% by mass of cement) and three curing conditions (no curing, curing by conventional water immersion and self/internal curing) are considered as the parameters of this investigation. A comparison was made between specimens not subjected to any curing, subjected to conventional wet curing and with those cured with hydrophilic compounds i.e., various self curing compounds. Mini slump flow test and V funnel tests were carried out to check the flowability as per EFNARC specifications [14]. A total of 384 cubes of size 100 mm × 100 mm × 100 mm were cast to determine the properties i.e. water retention, sorptivity, compressive strength and resistance to acid attack. The microstructure characteristics of SCM's are also investigated.

### 3.1. Materials

#### 3.1.1. Cement

53-grade OPC confirming to IS: 12269-1987 [15] was used in the investigation. It has a specific gravity of 3.12, specific surface area of 225 $m^2/g$ and initial and final setting times were 40 min and 560 min respectively.

#### 3.1.2. Fine aggregate

Local river sand confirming to Zone-2 according to IS: 383-1970 [16] was used as fine aggregate. The specific gravity and bulk density of sand were 2.65 and 1.45 $g/cm^3$ respectively.

#### 3.1.3. Fly ash

The fly ash used in this study was obtained from National Thermal Power Corporation (NTPC), Ramagundam (India). The fly ash has a specific gravity of 2.17. It has a composition consisting of silica content = 63.99%, (silica + alumina + iron oxide) content = 92.7%, calcium oxide = 1.71%, magnesium oxide = 1.0%, sulphuric anhydride = 0.73%, water and soluble salts = 0.04%, pH = 10 and loss on ignition = 2.12%.

#### 3.1.4. Water

Potable water was used in the investigations for both mixing and curing of SCM specimens.

#### 3.1.5. Super plasticizer

A polycarboxylate-type, new-generation high range water reducing admixture confirming to ASTM C494 [17], was used as super plasticizer for improving the flow or workability of mix with decreased water–cement ratio. These admixtures when they disperse in cement agglomerate significantly and reduce the viscosity of the paste forming a thin film around the cement particles.

#### 3.1.6. Hydrophilic chemicals

Polyethylene Glycols (PEGs) of low molecular (200) and high molecular weights (4000) were used in the study. The chemicals were mixed with water thoroughly prior to mixing of water in concrete. The details of the physical properties of the PEG compounds are shown in Table 1.

### 3.2. Mix proportions

Two mix proportions were selected (1:1 with *w/c* = 0.34 and 1:3 with *w/c* = 0.5) based on the trial and error method. The proportions of fly ash and super plasticizer have been altered to arrive at the SCM mixes meeting the required EFNARC specifications [14]. The final design mix adopted for two selected mixes is shown in Table 2.

### 3.3. Nomenclature of specimens

In this study, the nomenclature used for the SCM specimens of Mix-A (1:1 mortar mix) & Mix-B (1:3 mortar mix) are 'A' and 'B' respectively and PEG of molecular weights 200 and 4000 are denoted as 'L' and 'H'. 'N' and 'W' represent no curing and conventional water curing respectively with 0% dosage of curing chemical. The

**Table 1**
Physical properties of CARBOWAX PEGs.

| Product | Range of average molecular weight (g/mol) | Range of average hydroxyl number, Mg KOH/g | Liquid density, g/cc | | | Melting or freezing range, °C | Solubility in water at 20 °C, % by wt | Viscosity at 100 °C |
|---|---|---|---|---|---|---|---|---|
| | | | 20 °C | 60 °C | 80 °C | | | |
| PEG200 | 190–210 | 535–590 | 1.124 | 1.092 | 1.076 | −65 | Complete | 4.3 |
| PEG 4000 | 3600–4400 | 25–32 | Solid | 1.093 | 1.077 | 53–59 | 66 | 140.4 |

**Table 2**
Mixture proportions of SCMs (in $kg/m^3$).

| Mix | Cement | Fly ash | Sand | Water | SP |
|---|---|---|---|---|---|
| Mix-A (1:1) | 940.00 (1) | – | 940.00 (1) | 319.60 (0.34) | 1.88 (0.2%) |
| Mix-B (1:3) | 485.00 (1) | 97.00 (0.2) | 1455.00 (3) | 291.00 (0.5) | 1.75 (0.3%) |