



Identification of set-accelerator for enhancing the productivity of foam concrete block manufacture

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HIGHLIGHTS

- ▶ Study aims to identify an accelerator for foam concrete for early demoulding.
- ▶ Conventional accelerators did not reduce demoulding time.
- ▶ Though alum reduced demoulding time, higher dosage makes it uneconomical.
- ▶ Class-C fly ash is an appropriate accelerator for foam concrete made with SLS.

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ABSTRACT

Foam concrete is suitable for producing lightweight blocks. This paper deals with identification of suitable set accelerator for foam concrete made using sodium lauryl sulphate as foaming agent, i.e. facilitating demoulding within 2 h and also economical. As conventional accelerators, viz., calcium chloride, calcium nitrate, triethanol amine were not-effective in foam concrete, alum and Class-C fly ash were tried. Demoulding test was performed to the mixes having optimum density (1200–1300 kg/m³). Class-C fly ash was observed as a potential set-accelerator, facilitating demoulding at 90 min.

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1. Introduction

There has been renewed research interest in making use of light weight concrete blocks for wall construction. Attempts are being made to develop light weight solid, hollow and interlocking blocks. Foam concrete is more suitable for manufacturing of blocks. In foam concrete, macroscopic air foamed bubbles are produced mechanically and added to the base mix mortar during mixing. This type of foam concreting technique is called preformed foam concrete. Foaming agent required for producing aqueous stable foam can be either natural or synthetic origin.

Foam concrete is highly flowable and self-compacting in nature. Since the foam concrete contains air bubbles it cannot be rammed and vibrated in a machine to produce the blocks. Hence the foam concrete needs to be cast in mould. Normal foam concrete when cast in moulds, can be demoulded only after 24 h. This imposes constraints on the productivity of the block manufacture. This also demands a

large number of moulds thereby increasing high cost and will occupy large space. If the process of demoulding could be facilitated by reducing cycle time, the block production rate can be increased by reusing a reasonable number of moulds. Hence there is a need to identify suitable accelerator and its dosage which would reduce the setting time of foam concrete thereby facilitating early demoulding. Extensive research has been carried out on the use of set-accelerators in normal concrete. Most of the studies on foam concrete deal with identification of suitable foaming agent, properties of foam concrete, influence of filler type on fresh and hardened properties of foam concrete, air void characterisation of foam concrete [1–3]. No study has been reported on use of set-accelerator in foam concrete. In the case of foam concrete, the type of accelerator and the type of foaming agent influence its performance. This paper first reviews the studies on use of a few important set-accelerators in concrete, based on which a few accelerators are identified for the present study.

2. Review of studies on set-accelerators

Accelerators influence the rate of cement hydration, leading to a reduction in setting time reduces and an increase in early age

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strength of concrete. The accelerators are used for early removal of formwork, earlier finishing of surfaces, earlier attainment of strength to carry construction load. In cold-weather concreting, it accelerates the hydration process because of low temperature and also prevents damage due to freezing. Acceleration is normally achieved by (i) accelerating the tricalcium aluminate phase (C_3A) of Portland cement (Rapid set accelerators), or (ii) accelerating the tricalcium silicate phase in cement (Accelerators for setting and hardening). Out of the various chemicals reported in literature a brief review of studies on calcium chloride, calcium nitrate, triethanol amine, lithium salts and calcium formate as set-accelerator has been presented.

2.1. Calcium chloride

It acts as a catalyst and promotes the hydration of C_3S and C_2S or reduction in alkalinity of the pore solution promotes the hydration of silicates [4]. Usual dosage is 2% by the weight of cement [5]. Ramachandran [6] studied the hydration characteristics of C_3S in the presence of $CaCl_2$, and observed that $CaCl_2$ alters the rate of hydration and also chemical composition of C–S–H. In the mix containing 2% $CaCl_2$ the setting time is reported to occur at 105 min, while it was 790 min for the mix without $CaCl_2$. The presence of $CaCl_2$ leads to corrosion of reinforcement bars [4]. For reactive aggregates the addition of $CaCl_2$ increases the reactivity of alkali-silica reaction there by deteriorating the concrete [6].

2.2. Calcium nitrate (CN)

Justness and Nygaard [7] studied the efficiency of CN as a set-accelerator for different cements at low temperature and observed that the set-accelerator efficiency of CN increases with an increase in belite content of cement. The optimum dosage of CN with ASTM type I cement is 3.86% the weight of cement. CN was observed to accelerate the C_3A phase. Hydration mechanisms were modified which resulted in altered products. Aggoun et al. [8] studied the set-accelerator efficiency of CN and concluded that it depends on chemical composition cement.

2.3. Triethanolamine (TEA)

Depending upon the cement type and addition rate TEA can produce either set-acceleration or retardation, i.e., it is a dosage sensitive admixture [9]. In the presence of TEA, the reaction between C_3A and gypsum gets accelerated and ettringite is

converted into monosulfoaluminate. Ramachandran [10] reported that the initial setting characteristics were drastically reduced at a dosage of 0.1%, and 0.5% weight of cement. Aiad et al. [11] studied on alkanolamines on the rheological and setting properties of cement paste and reported that TEA accelerate the setting time at a dosage of 0.1% only.

2.4. Lithium salts

Novinson and Crahan [12] studied the use of lithium salts as a set accelerator for refractory concretes. The reaction rates are related to the pH of the lithium salts in mixing water. The lithium cation has more effect than other cation (like Na, K) because of its smaller size, higher hydration energy and simple electronic structure (lithium has smaller crystal radii of 0.6 Å, it has higher hydration energy of 123 kcal/mol when compared to sodium or potassium whose crystal radii is 0.95, 1.33 Å having hydration energy of 97 and 77 kcal/mol receptively). The class of anion is also very important as it controls the rate of lithium hydration (lithium acts as a catalyst. Lithium cation is smaller in size when compared to sodium and magnesium as a result lithium has higher hydration energy and it coordinate with many water molecule per atom to hydrate faster). Lithium salts is reported to acts as quick set accelerator with the anion like carbonate, nitrate, fluoride and tetraborate.

2.5. Calcium formate

The solubility of calcium formate at room temperature is 15%. Singh and Abha [13] concluded that calcium formate accelerates the C_3S hydration with the dosage of 0.5–6%. The effect of calcium formate depends up on composition of cement. For cements with C_3A/SO_3 ratio higher than four, calcium formate is reported to process good potential for acceleration in strength.

The above review has helped in identifying most widely used/ studied accelerators, their behaviour, hydration mechanism and dosage ranges to be tried. This paper deals with the experimental investigation conducted to ascertain the setting of foam concrete (evaluated through shape retention while demoulding of cubes) using identified set accelerators. The objective is to identify accelerators which have the capacity to retain its shape after demoulding within 2 h. As a first stage, the cost effectiveness of the reviewed accelerators (calcium chloride ($CaCl_2$), calcium nitrate (CN), and triethanolamine (TEA)) based on the dosage recommended in literature have been tried initially. As a next stage,

Table 1
Chemical properties of Ordinary Portland Cement (OPC) and Class-C fly ash.

S. no.	Properties Chemical composition	Cement		Class-C fly ash	
		% by mass	IS 12269-1987	% by mass	ASTM C 618 (Class-C)
1	CaO	62.04	–	11.85	>10
2	SiO ₂	20.80	–	46.58	–
3	Al ₂ O ₃	4.76	–	20.87	–
4	Fe ₂ O ₃	3.96	–	8.20	–
5	MgO	1.88	6	1.52	5 (max)
6	SO ₃	2.21	2.5	2.53	–
7	Insoluble residue	0.54	–	–	–
8	Total loss on Ignition	3.93	4	2.81	–
9	Total chloride (as Cl)	0.01	–	0.04	–
10	Na ₂ O	0.28	–	0.43	–
11	K ₂ O	0.20	–	0.17	–
12	Total alkalis	0.41	–	–	–
13	TiO ₂	0.19	–	–	–
14	(Mn ₂ O ₃)	0.33	–	–	–
15	Al ₂ O ₃ /Fe ₂ O ₃	1.20	0.66	–	–
16	SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	–	–	75.65	50 (min)

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