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Evaluation of initial setting time due to superplasticizers

Abhishek Singh [a,*], Shobha Ram [a], Alok Verma [b]

[a] *Department of Civil Engineering, Gautam Buddha University, Uttar Pradesh, India*
[b] *Department of Civil Engineering, Delhi Technological University, Delhi, India*

ABSTRACT

This paper shows how polycarboxylate based superplasticizer affects the initial setting time of cement paste. Three superplasticizers are used in this study with different properties and aiming to determine the delay in initial setting time due to superplasticizer. Initial setting time is calculated as per IS: 4031-PART 5-1988 with different SP dosages (0.5%, 0.75%, 1.0% and 1.5% of weight of cement). Superplasticizer is an admixture which reduces the water-cement ratio or increase the workability at the same water content. This paper deals with the evaluation of initial setting time due to superplasticizers.

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1. Introduction

Setting time of cement paste is characterized as the time required for the move of cement paste from fluid phase to solid phase. It is vital to recognize this stage as this stage helps in setting and transporting cement paste. Superplasticizer (S.P) is a type of water reducers, however, the difference between superplasticizer and water reducer is that superplasticizer will significantly reduce the water required for concrete mixing. Generally, there are four main categories of superplasticizer: sulfonated melamine formaldehyde condensates, sulfonated naphthalene formaldehyde condensates, modified lignosulfonates and others such as sulfonic-acid esters and carbohydrate esters (Alsadey, 2015). In this study, polycarboxylate ether based superplasticizer is used. It consists of a carboxylic ether polymer with long side chains. Toward the start of the mixing process it starts an indistinguishable electrostatic scattering mechanism from the customary superplasticizers, however the side chains connected to the polymer spine produces a steric hinderance which enormously balances out the concrete particles capacity to separate and disperse. Steric hinderance gives a physical obstruction (nearby the electrostatic boundary) between the cement grains. With this procedure, flowable paste with incredibly decreased water content is obtained.

Superplasticizers are frequently used in order to improve the workability of mortar and concrete mixes for demanding applications. The addition of superplasticizers aims at two objectives: first, the addition of superplasticizers allows controlling the flow properties, which are of major importance for the design of self-compacting concretes, and second, superplasticizers allow the reduction of the water to cement ratio while maintaining workability in order to reach high strength and durability. The cement–water system is highly sensitive to the addition of superplasticizers. Small amounts of superplasticizers enhance the workability properties efficiently, but are often associated with strong, undesired retardation phenomena of the setting of the cement paste (Zingg et al., 2009).

Impact of superplasticizer on compressive quality have been explored by Papo and Piani (2004), Sakai et al. (2006), Shi et al. (2009), and Kadri et al. (2009). Setting and hardening of cement relies on upon numerous elements, for example, water-bond proportion, bond quality, nature of solid material, quality control amid generation of cement and so forth (Mahmoud et al., 2010; Sukumar and Silva, 2016). SP cause better scattering and effect of superplasticizers on porosity have been seen (Memon et al., 2002; Liao et al., 2004; Gastaldini et al., 2009).

* *Corresponding author*. Tel.: +91-999-9471478 ; E-mail address: abhishek180694@gmail.com (A. Singh)
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Adsorption, fluidity and hydration property have been studied and it has been reported that use of superplasticizers improves these properties (Yoshiokaa et al., 2002; Kong et al., 2006; Plank and Hirsch, 2007; Mikanovic and Jolicoeur, 2008; Pei et al., 2008). Durability, pore size distribution and rheological properties have been investigated and beneficial effect of superplasticizer have been reported (Caszewski and Szwabowski, 2004; Houst et al., 2008; Roziere et al., 2009; Li et al., 2009; Felekoglu et al., 2009).

Effect of Superplasticizers on setting time and has been compared with other superplasticizer having different base (Palacios et al., 2009; Zhang et al., 2010). In practice, the initial set indicates the loss of workability and the beginning of the stiffening of the paste.

2. Experimental Programme

It was intended to observe the effect of superplasticizer on setting of cement pastes when mixed in different dosages and to compare the performances of various superplasticizers. The experimental programme included the use of three types of superplasticizers with different properties.

In present investigations, four superplasticizer dosages (0.5%. 0.75%, 1%, 2% of weight of cement) are provided in cement and cement paste is prepared with the desired consistency. Abbreviations of some cement mix designations are explained below in Table 1. Superplasticizer properties are given below in Table 2 respectively. Vicat apparatus was used as per standard procedure with different dosages of the three superplasticizers and their effect on initial setting time has been seen as per IS: 4031-PART 5-1988 respectively. Penetration readings were taken after every 5 minutes to assess change in rheological properties.

Table 1. Explanation of mortar mix designations.

Typical Mix Designation	Explanation
C1-0%	Cement Type 1 SP Dosage 0%
C2-0%	Cement Type 2 SP Dosage 0%
C3-0%	Cement Type 2 SP Dosage 0%

Table 2. Characteristics of superplasticizer.

Type	Solid Content	Specific Gravity	pH	Grade
Type-1	40%	1.1	5	Neutral
Type-2	60%	1.58	8	Alkaline
Type-3	70%	1.05	>6	Alkaline

3. Results and Discussion

Cement pastes with different dosages of Superplasticizers were prepared and penetration of needle after every five minutes is noted which is described in Tables 4-6 respectively included graphs with trendline equations.

It has been investigated that there is a delay in initial setting time with increase in superplasticizer dosage. Consistency of the cement paste decreases with increase of superplasticizer as shown in Table 3.

Table 3. Consistency of superplasticizers.

SP Type	Dosage	Consistency
Type -1	0.5%	29.5%
	0.75%	28.55%
	1.0%	27.7%
	1.5%	26.5%
Type -2	0.5%	28.75%
	0.75%	28.12%
	1.0%	27.4%
	1.5%	26.65%
Type -3	0.5%	25.75%
	0.75%	24.5%
	1.0%	23.5%
	1.5%	22.0%

Table 4. Penetration at every 5 minutes for Type-1 SP.

Time (minutes)	SP Dosage (%)			
	0.5%	0.75%	1.0%	1.5%
0	0	0	0	0
5	0	0	0	0
10	0	0	0	0
15	0.5	0	0	0
20	1.5	1.0	0	0
25	2.0	1.5	0	0
30	2.5	2.0	0.5	0
35	3.0	2.5	1.0	0
40	4.0	3.0	1.5	0
45	4.5	3.5	2.0	0.5
50	5.50	4.0	2.5	1.0
55		5.0	3.0	1.5
60		6.0	3.5	1.8
65			4.5	2.0
70			4.8	2.5
75			5.5	3.0
80				3.5
85				4.0
90				4.5
95				6.0
IST (minutes)	50	60	75	95

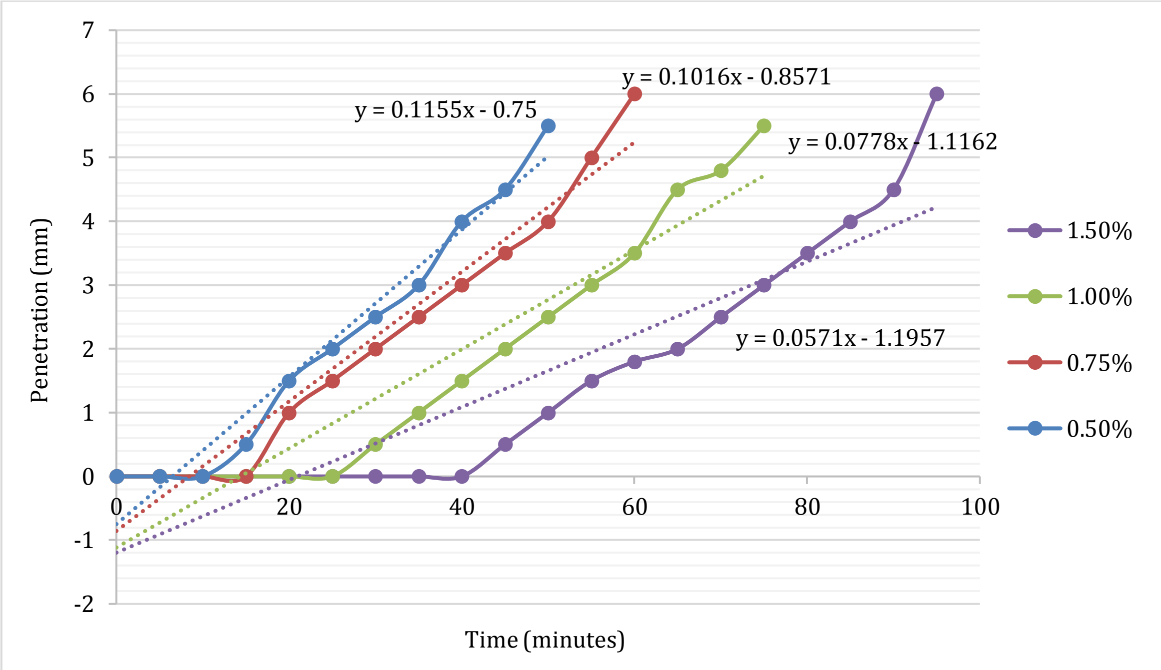

Fig. 1. Penetration for Type-1 superplasticizer.

Table 5. Penetration at every 5 minutes for Type-2 SP.

Time (minutes)	SP Dosage (%)			
	0.5%	0.75%	1.0%	1.5%
0	0	0	0	0
5	0	0	0	0
10	0	0	0	0
15	2.0	0	0	0
20	3.0	0.5	0	0
25	3.5	1.0	0	0
30	4.0	1.5	0.5	0
35	4.5	2.5	1.0	0
40	5.0	3.0	1.5	0.5
45	5.5	4.5	2.5	1.0
50		4.8	3.0	1.0
55		5.5	3.5	1.5
60			4.0	2.0
65			4.0	2.5
70			5.5	3.5
75				4.0
80				5.0
85				5.5
IST (minutes)	45	55	70	85

Table 6. Penetration at every 5 minutes for Type-3 SP.

Time (minutes)	SP Dosage (%)			
	0.5%	0.75%	1.0%	1.5%
0	0	0	0	0
5	0	0	0	0
10	0.5	0	0	0
15	1.5	0	0	0
20	2.5	0.5	0	0
25	3.0	1.5	0	0
30	3.5	2.5	0	0
35	4.5	3.5	0.5	0
40	5.5	4.0	1.5	0.5
45		4.5	2.0	1.0
50		6.0	2.5	1.5
55			3.5	2.5
60			4.5	3.0
65			5.5	3.5
70				4.5
75				5.5
IST (minutes)	40	50	65	75

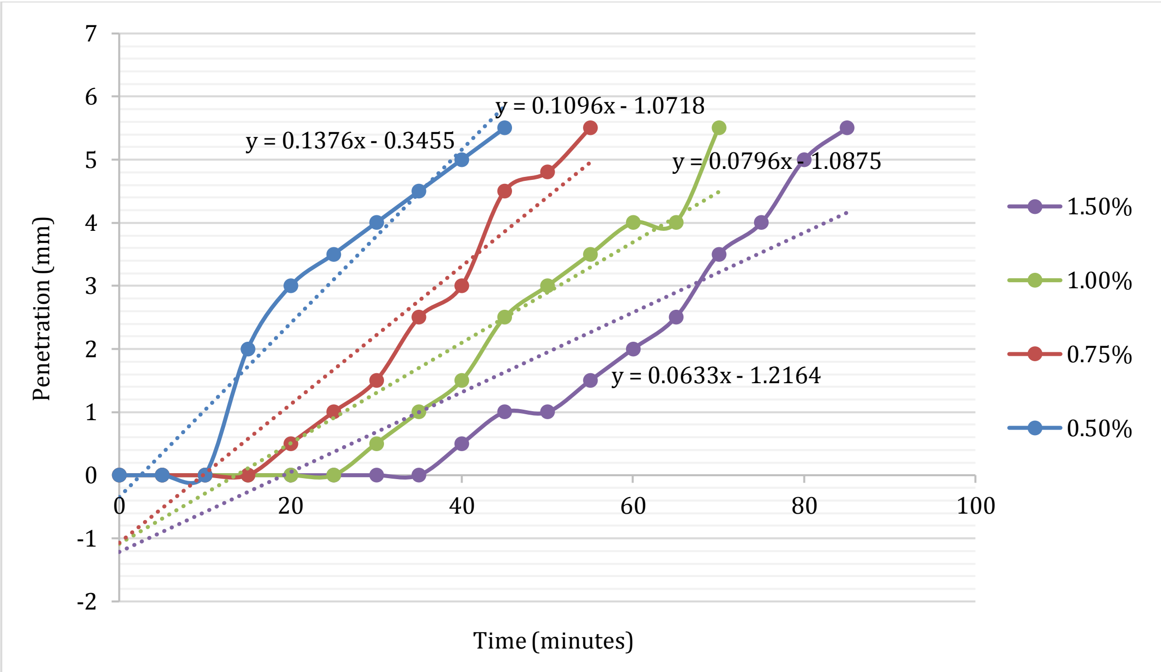

Fig. 2. Penetration for Type-2 superplasticizer.

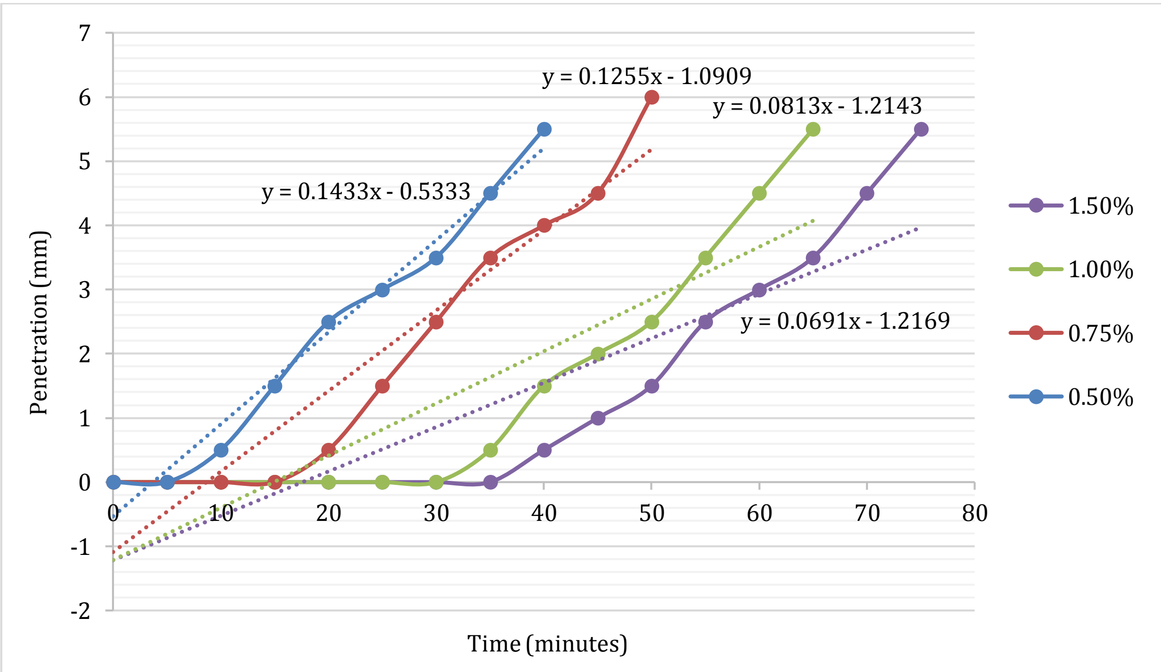

Fig. 3. Penetration for Type-3 superplasticizer.

From Fig. 1, it is seen that there is significant increase of 20% in initial setting time when dosage increased to 0.75% from 0.5%. However increase of nearly 26% is experienced when dosage increased to 1% from 0.75% and from 1% to 1.5%. Increase of 50% in initial setting time when SP dosage increased directly to 1% from SP dosage 0.5% of weight of cement.

For type-2 superplasticizer it can be seen that there is an increase of 22% in initial setting time when dosage increased to 0.75% from 0.5%, however increase of nearly 15% increase is experienced when dosage increased to 1% from 0.75% and from 1% to 1.5%. Increase of 55% in initial setting time is there when SP dosage increased directly to 1% from SP dosage of 0.5% of weight of cement.

It has been investigate that in type-3 superplasticizer there is increase of 25% in initial setting time when dosage increased to 0.75% from 0.5%, however increase of nearly 20% increase is experienced when dosage increased to 1% from 0.75% and from 1% to 1.5%. Increase of approximately 62% in initial setting time when SP dosage increased directly to 1% from SP dosage 0.5% of weight of cement.

4. Conclusions

Since the initial setting time indicates the loss of workability to such an extent that the paste is no longer workable, the initial setting time is determined by the penetration depth test of the cement pastes via vicat apparatus. A superplasticizer reduces the required water cement ratio but at the same time delays the setting time of cement paste.

- It is seen that type-1 superplasticizer reduces up to 30% water whereas type-2 Superplasticizer reduces 40% water and type-3 reduces 45% water. This indicates that initial setting time of cement can be modified and regulated with the use of superplasticizers.
- Since the use of SP delays setting, the timing and effect of redosages of SP can be worked out, as indicated by zeros in table 4, 5 and 6 respectively.
- Effectiveness of various SPs could be compared by examining delay of initial setting time with percentage of dosages, as provided in last rows of table 4, 5 and 6 respectively.
- Indicative equations are shown for different curves in Figs. 1-3 which may be used to provide data about consistency before initial setting is complete.

REFERENCES

Alsadey S (2015). Effect of superplasticizer on fresh and hardened properties of concrete. *Journal of Agricultural Science and Engineering,* 1(2), 70-74.

Caszewski JC, Szwabowski J (2004). Influence of superplasticizers on rheological behaviour of fresh cement mortars. *Cement and Concrete Research,* 34, 235–248.

Felekoglu B, Turkel S, Kalyoncu H (2009). Optimization of fineness to maximize the strength activity of high-calcium ground fly ash – Portland cement composites. *Construction and Building Materials,* 23, 2053–2061.

Gastaldini ALG, Isaia GC, Hoppe TF, Missau F, Saciloto AP (2009). Influence of the use of rice husk ash on the electrical resistivity of concrete: A technical and economic feasibility study. *Construction and Building Materials,* 23, 3411–3419.

Houst YF, Bowen P, Perche F, Kauppi A, Borgett P, Galmiche L, Le Meins J-F, Lafuma F, Flatt RJ, Schober I, Banfill PFG, Swift DS, Myrvold BO, Petersen BG, Reknes K (2008). Design and function of novel superplasticizers for more durable high performance concrete (superplast project). *Cement and Concrete Research,* 38, 1197–1209.

Kadri E-H, Aggoun S, De Schutter G (2009). Interaction between C3A, silica fume and naphthalene sulphonate superplasticiser in high performance concrete. *Construction and Building Materials,* 23, 3124–3128.

Kong HJ, Bike SG, Li VC (2006). Effects of a strong polyelectrolyte on the rheological properties of concentrated cementitious suspensions. *Cement and Concrete Research,* 36, 851–857.

Li G, Xiong G, Lu Y, Yin Y (2009). The physical and chemical effects of long-term sulphuric acid exposure on hybrid modified cement mortar. *Cement & Concrete Composites,* 31, 325–330.

Liao K-Y, Chang P-K, Peng Y-N, Yang C-C (2004). A study on characteristics of interfacial transition zone in concrete. *Cement and Concrete Research,* 34, 977–989.

Mahmoud AAM, Shehab MSH, El-Dieb AS (2010). Concrete mixtures incorporating synthesized sulfonated acetophenone–formaldehyde resin as superplasticizer. *Cement & Concrete Composites,* 32, 392–397.

Memon AH, Radin SS, Zainc MFM Trottier J-F (2002). Effects of mineral and chemical admixtures on high-strength concrete in seawater. *Cement and Concrete Research,* 32, 373–377.

Mikanovic N, Jolicoeur C (2008). Influence of superplasticizers on the rheology and stability of limestone and cement pastes. *Cement and Concrete Research,* 38, 907–919.

Palacios M, Houst YF, Bowen P, Puertas F (2009). Adsorption of superplasticizer admixtures on alkali-activated slag pastes. *Cement and Concrete Research,* 39, 670–677.

Papo A, Piani L (2004). Effect of various superplasticizers on the rheological properties of Portland cement pastes. *Cement and Concrete Research,* 34, 2097–2101.

Pei M, Wang Z, Li W, Zhang J, Pan Q, Qin X (2008). The properties of cementitious materials superplasticized with two superplasticizers based on aminosulfonate–phenol–formaldehyde. *Construction and Building Materials,* 22, 2382–2385.

Plank J, Hirsch C (2007). Impact of zeta potential of early cement hydration phases on superplasticizer adsorption. *Cement and Concrete Research,* 37, 537–542.

Roziere E, Loukili A, El Hachem R, Grondin F (2009). Durability of concrete exposed to leaching and external sulphate attacks. *Cement and Concrete Research,* 39, 1188–1198.

Sakai E, Kasuga T, Sugiyama T, Asaga K, Daimon M (2006). Influence of superplasticizers on the hydration of cement and the pore structure of hardened cement. *Cement and Concrete Research,* 36, 2049–2053.

Shi H-S, Xu B-W, Zhou X-C (2009). Influence of mineral admixtures on compressive strength, gas permeability and carbonation of high performance concrete. *Construction and Building Materials,* 23, 1980–1985.

Sukumar B, Silva J (2016). Effect of polymeric admixtures on self-compacting concrete. *International Journal of Innovative Research in Science, Engineering and Technology,* 5(1), 660-665.

Yoshiokaa K, Tazawa E, Kawai K, Enohata T (2002). Adsorption characteristics of superplasticizers on cement component minerals. *Cement and Concrete Research,* 32, 1507–1513.

Zhang M-H, Sisomphon K, Ng TS, Sun DJ (2010). Effect of superplasticizers on workability retention and initial setting time of cement pastes. *Construction and Building Materials,* 24, 1700–1707.

Zingg A, Winnefeld F, Holzer L, Pakusch J, Becker S, Figi R, Gauckler L (2009). Interaction of polycarboxylate-based superplasticizers with cements containing different C3A amounts. *Cement & Concrete Composites,* 31, 153–162.