

# Study on Compressive Strength and Setting Times of Fly Ash Concrete after Slump Recovery Using Superplasticizer

Chaiyakrit Raoupatham, Ram Hari Dhakal, Chalermchai Wanichlamert

**Abstract**—Fresh concrete has one of dynamic properties known as slump. Slump of concrete is design to compatible with placing method. Due to hydration reaction of cement, the slump of concrete is loss through time. Therefore, delayed concrete probably get reject because slump is unacceptable. In order to recover the slump of delayed concrete the second dose of superplasticizer (naphthalene based type F) is added into the system, the slump recovery can be done as long as the concrete is not setting. By adding superplasticizer as solution for recover unusable slump loss concrete may affects other concrete properties. Therefore, this paper was observed setting times and compressive strength of concrete after being re-dose with chemical admixture type F (superplasticizer, naphthalene based) for slump recovery. The concrete used in this study was fly ash concrete with fly ash replacement of 0%, 30% and 50% respectively. Concrete mix designed for test specimen was prepared with paste content (ratio of volume of cement to volume of void in the aggregate) of 1.2 and 1.3, water-to-binder ratio (w/b) range of 0.3 to 0.58, initial dose of superplasticizer (SP) range from 0.5 to 1.6%. The setting times of concrete were tested both before and after re-dosed with different amount of second dose and time of dosing. The research was concluded that addition of second dose of superplasticizer would increase both initial and final setting times accordingly to dosage of addition. As for fly ash concrete, the prolongation effect was higher as the replacement of fly ash increase. The prolongation effect can reach up to maximum about 4 hours. In case of compressive strength, the re-dosed concrete has strength fluctuation within acceptable range of  $\pm 10\%$ .

**Keywords**—Compressive strength, Fly ash concrete, Second dose of superplasticizer, Slump recovery, Setting times.

## I. INTRODUCTION

IN practice, concrete is design based on slump and strength class, so that it compatible with construction methods and structure usage. In case of construction got delay and freshly mixed concrete was leave for period, concrete was started to loss its slump and turn rigid. When concrete become rigid and unable to work will probably get reject but concrete can recover slump back to the original by adding second dose of superplasticizer (naphthalene base type F). The use of chemical admixtures for rettempering, can effects on the

rheological properties and the ultimate mechanical characteristics of concrete depending on the amount and the type of admixtures used [1]. Therefore, it need to be observed the effect of second dose of superplasticizer on concrete, while this paper focuses on most general properties, which were setting times and compressive strength. Setting times need to be observed, so that it can estimate usage time of concrete after re-dosed or time which concrete start to develop strength and formwork removal time to continue next section. While compressive strength need to be observed to make sure that it was fluctuate within acceptable range.

## II. EXPERIMENTAL

### A. Materials

**Cement:** Ordinary Portland cement Type I was used. The physical and chemical compositions of cement are shown in Table I according to ASTM C150

TABLE I  
CHEMICAL/PHYSICAL PROPERTIES OF CEMENT, FLY ASH AND AGGREGATE USED

Chemical/Physical Properties of Powder		
Ingredients:	OPC I	Fly Ash
CaO (%)	64.28	20.01
SiO <sub>2</sub> (%)	20.35	33.41
Al <sub>2</sub> O <sub>3</sub> (%)	5.02	18.74
Fe <sub>2</sub> O <sub>3</sub> (%)	3.18	15.03
MgO (%)	2.03	2.02
Na <sub>2</sub> O (%)	0.20	1.27
K <sub>2</sub> O (%)	0.48	2.92
SO <sub>3</sub> (%)	2.92	5.19
Specific Gravity	3.15	2.24
Blaine Fineness (cm <sup>2</sup> /g)	3440	2800
Loss on Ignition (%)	1.43	0.23
Physical Properties of Aggregate		
Physical Properties of Aggregate	Gravel	Sand
Specific gravity	2.71	2.60
Fineness modulus	7.98	2.45
Water absorption (%)	0.70	1.06

**Fly ash:** Fly ash conforms to class 2A, TIS.2135 from Mae Moh Power Plant in Lampang Province was used. The physical and chemical composition is as shown in Table I.

**Aggregate:** The natural river sand passing through sieve no. 4 and naturally found in Thailand was used as the fine aggregate and crushed limestone with the maximum size of 25mm conformed to ASTM C 33 was used as the coarse

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aggregate. The physical properties of coarse and fine aggregates (gravel and sand) are shown in Table I.

*Chemical Admixture (Superplasticizer):* Naphthalene based Superplasticizer (SP) according to ASTM C494 commercially available and widely used in Thailand was used.

#### B. Paste Content ( $\gamma$ )

Paste content was parameter used to define minimum paste volume needed to fill up void between aggregate, in order to make concrete dense. Fig. 1 shows the graph obtained from void analysis described on the ASTM C29, where sand-aggregate ratio of 0.42 gave a minimum void between aggregate.

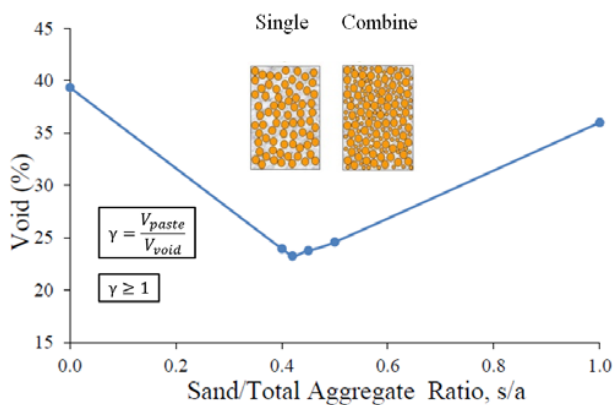


Fig. 1 Minimum void concept

#### C. Second Dose of Superplasticizer

Ready-mix concrete is concrete that manufactured at plant and later delivering to site [2]. Due to the delivering process, ready-mix concrete faces the problem of slump loss from delayed usage. Therefore, second dose of superplasticizer is introduced as a technique that used for concrete slump recovery. The principal causes of slump loss can be largely divided into two parts, chemical and physical coagulation. Chemical coagulation is produced by reaction between chemical admixture and cement component as hydration occurs. Physical coagulation is caused by collision of cement particles. Slump loss of cement paste also could result from drop of dispersive capacity caused by vanishing of dispersant with time elapsed [3]. When concrete loss its slump and become unusable, it will probably be rejected. Therefore, second dose of superplasticizer was introduced into concrete system to create electrostatic repulsive force and regain the slump. As per studies, it is recommended that, adjustment of slump of concrete by second dose of superplasticizer should be done within 90 minute after mixing [4].

#### D. Mix Proportion

Mix design of concrete was prepared for water-to-cement ratio (w/c) of 0.3-0.58 respectively. Volumetric of paste to void ( $\gamma$ , Paste content) varying from 1.2 to 1.3 with fly ash replacement ratio of 0, 30 and 50%. Sand-to-aggregates ratio (S/A) was fixed as 0.42 and percentage of void between aggregates equal to 23%.

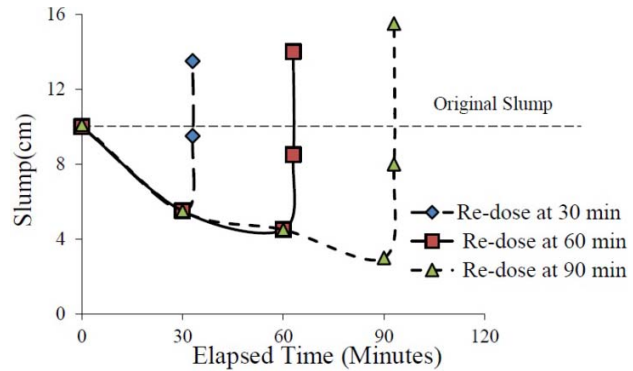


Fig. 2 Concept of Re-Dose

#### E. Compressive Strength

Cylindrical specimens of size 100mm in diameter and 200mm in length were used for measuring the compressive strength development at the ages of 1, 7 and 28 days, respectively. The test specimens were sealed with a plastic wrap after casting and removing mold after 24 hour. Specimens were cured in water at  $28 \pm 2^\circ\text{C}$  till the time of testing.

#### F. Setting Times Measurement

Setting times of concrete was measured as per the method described in ASTM C403M. Initial setting times and hardness development of mortar (final setting times) taken by sieving concrete. This test procedure was in accordance with ASTM C403 M.

### III. RESULTS AND DISCUSSION

#### A. Setting Times and Compressive Strength of OPC Concrete

Effect of second dosage of superplasticizer is shown in Figs. 3 and 4. Fig. 3 shows the effect of second dose of superplasticizer on high water-binder ratio concrete, where the setting times of both initial and final were slightly increase as the second dose increase from 0%, 0.6% and 0.8%. The prolongation was about 30 minute from non-re-dose concrete. Fig. 4 shows the effect of second dose of superplasticizer on low water-binder ratio concrete, where the setting times of both initial and final were slightly increase as the second dose increase from 0% to 1.0% and it will drastically increase as the second dose exceeding 1.0%. When water-to-binder ratio is reduced with fixed dosage of superplasticizer, the initial and final setting times are also reduced [5].

The setting time of concrete was prolonged after second dose of superplasticizer is added because additional superplasticizer will disturb cement hydration. In case of high water-cement ratio (Fig. 3), the second dose of superplasticizer that required for recovering slump was lower compared to low water-cement ratio (Fig. 4). Therefore, the prolongation effect due to additional dose of superplasticizer was little. Moreover, in case of low water-cement ratio, where the setting times of concrete drastically increase, this may come from the overdosing of superplasticizer.

Figs. 5 and 6 reveal that by using second dose of superplasticizer to recover slump loss concrete has unnoticeable effect on compressive strength of OPC concrete.

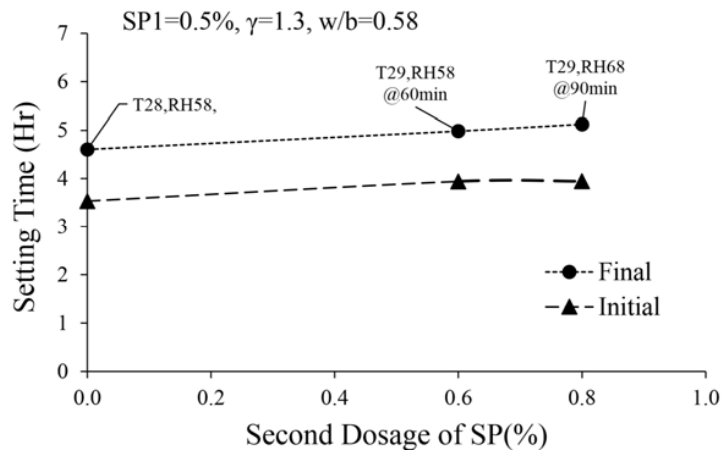


Fig. 3 Effect of second dose on setting times of high water-binder ratio OPC concrete

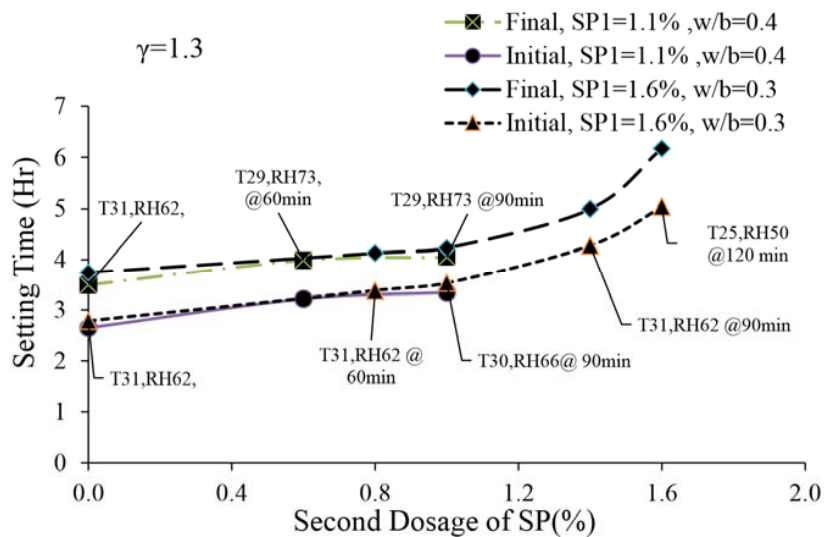


Fig. 4 Effect of second dose on setting times of low water-binder ratio OPC concrete

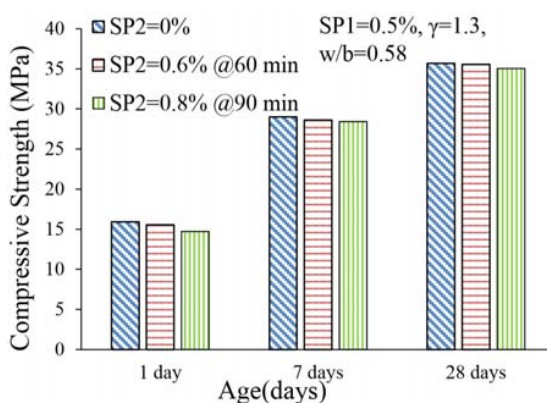


Fig. 5 Effect of second dose on compressive strength of high water-binder ratio concrete

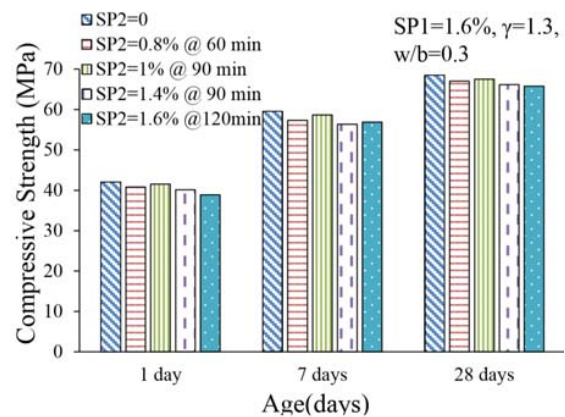


Fig. 6 Effect of second dose on compressive strength of low water-binder ratio concrete

### B. Setting Times and Compressive Strength of Fly Ash Concrete

Figs. 7 and 8 show the setting times of concrete before and after re-dosing with different second dosage and time of dosing. Fig. 8 compared the prolongation effect of high water-cement ratio fly ash concrete to OPC concrete, where the prolongation effect of fly ash concrete is greater. The setting times of fly ash concrete of both initial and final were slightly increase as second dose increase from 0% to 0.3% and drastically increase after the second dose exceeding 0.3%. Fig. 7 compared low water-cement ratio fly ash concrete with different replacement ratio, where the result have proven that the second dose of superplasticizer prolongation effect was larger as the fly ash replacement increase, which clearly shown in the graph that the prolongation was drastically increase for any amount of second dose added. Figs. 7 and 8 clearly show that, higher fly ash replacement percentage the prolongation effect of second dosage of superplasticizer will be higher.

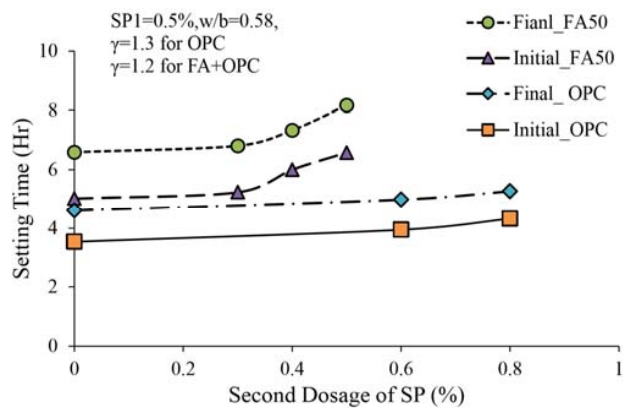


Fig. 7 Effect of second dose on setting times of high water-binder ratio FA and OPC concrete

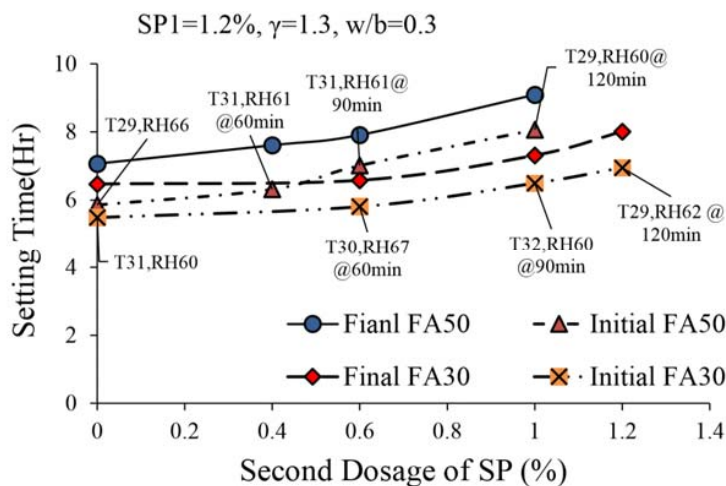


Fig. 8 Effect of second dose on setting times of low water-binder ratio fly ash concrete

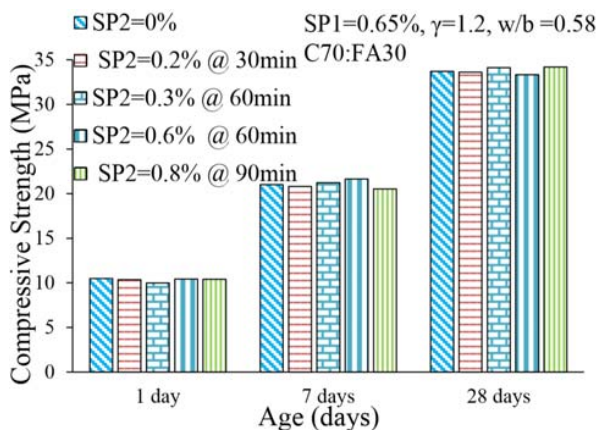


Fig. 9 Effect of second dose on compressive strength of high water-binder ratio 30% fly ash concrete

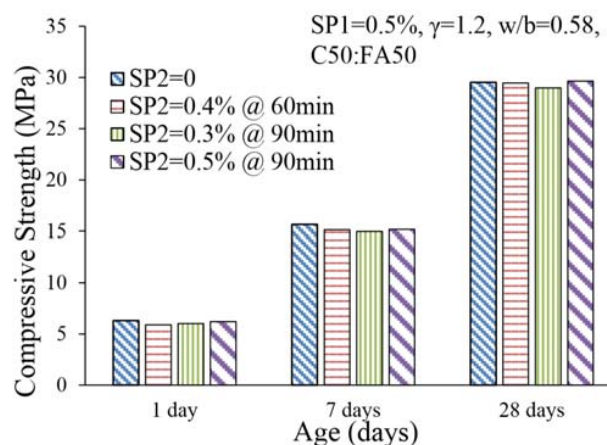


Fig. 10 Effect of second dose on compressive strength of low water-binder ratio 50% fly ash concrete



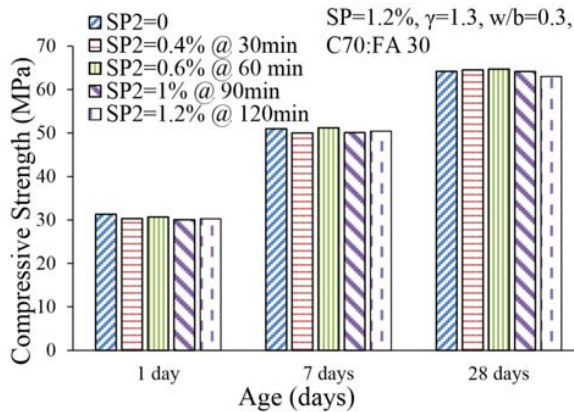


Fig. 11 Effect of second dose on compressive strength of low water-binder ratio 30% fly ash concrete

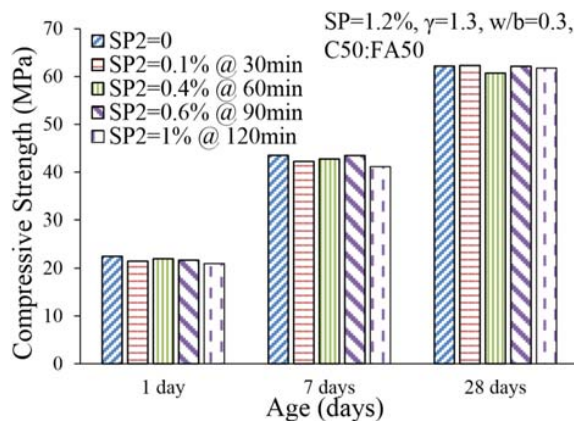


Fig. 12 Effect of second dose on compressive strength of low water-binder ratio 50% fly ash concrete

Setting times is the result of hydration of cement, producing microscopic mineral products that link adjacent cement grains to each other. As hydration progress, each cement grain is bound more tightly to its neighbors, so that the fresh concrete has higher resistance to deformation. Since, cement hydration drives concrete setting. The observed retardation in setting times can be mainly attributed to the combined effect of a lower cement content and a higher “effective super-plasticizer dosage” relative to the weight of cement for these concrete mixes, since part of the cement was replaced by the fly ash. Therefore, for the concrete mixes containing fly ash, due to lower amount of cement and higher effective superplasticizer dosage, a greater retarding effect could be expected. For the cement only concrete, which has higher cement content and lower effective superplasticizer dosage in comparison to mixes containing fly ash, the cement particles are expected to be more closely packed. This could result in greater inter-particle contact, and thus could speed up setting.

Figs. 9-12 reveal that by using second dose of superplasticizer to recover slump loss concrete will not effect on compressive strength of OPC concrete.

#### ACKNOWLEDGEMENTS

Authors would like to thank the Center of Excellence in Material Science, Construction and Maintenance Technology, Thammasat University (Thailand), and Kochi University of Technology (Japan) for their financial and scholarship support.

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