# RE-DOSING SUPERPLASTICIZER TO REGAIN SLUMP ON CONCRETE WITH FLY ASH


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## ABSTRACT

This research is preliminary study about addition of second dose of superplasticizer to regain the slump, after it losses certain percentage of slump in concrete with Fly Ash (FA). The test was conducted on the concrete mix with cement replacement by FA. The cement was replaced with 20% FA and 30% FA respectively. Concrete mix designed for test specimen was prepared with the paste (ratio of volume of cement to volume of void in the aggregate) contain of 1.2, water to cement ratio of range 0.55 to 0.7, initial dose of superplasticizer range from 0.2 to 1 percentages and naphthalene based superplasticizer. Re-dosing of superplasticizer was done in 30, 60, 90 minutes respectively. The research was concluded that addition of second dose of superplasticizer is possible to regain the slump in field and there is certain relation between percentage slump loss and second dose of superplasticizer. It is also found that there is not any adverse affect on compressive strength of due to addition of second dose of SP in concrete with FA. This research will help to solve slump loss problem of ready mix concrete during delivery time.



**Keywords:** Concrete, Fly Ash, Re-dosing, Slump, Superplasticizer.


## 1. INTRODUCTION

In beginning many researchers devoted themselves to the research of the potential activity of FA and the hydration process of fly ash cement. With the deepening of the cognition for fly ash properties, some people found that the particles of fly ash have the morphology that is different to other pozzolanic materials. It is the unique particle morphology to make it have the ability reducing water, which other pozzolanic materials do not have [1-4]. It influences not only rheological property of fresh mortar but also initial structure of hardened cement stone. Use of fly ash to partially replace cement improves many properties of concrete especially durability properties such as increasing workability and pumpability, improving long-term strength, reducing shrinkage,

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improving resistance against chloride-induced steel corrosion, increasing sulphate resistance, reducing risk due to alkali-aggregate reaction, although some properties of fly ash concrete, such as initial strength, carbonation and freezing and thawing resistance have been found to be inferior than the concrete without fly ash.[5] In regard of environment, cement substitution reduces depletion of natural resources used for cement production. It also reduces energy used for clinkerization, then reduce gases emitted to the environment especially $CO_2$. It estimated that about one ton of $CO_2$ is released per ton of clinker. [6] Due to the above regions now a day's fly ash is being popular binder not only to fulfill the minimum powder content but also to replace cement for ready mix concrete to reduce cost.

Ready mix concrete is ordered based on workability (slump class) and strength class. Superplasticizer is added to the ready mix concrete at factory to get desired slump. In practice workability is desirable property of concrete at site when pouring and compacting it, but during fresh state it loses workability with elapsed of time. In case of long haul involved specially in delivering ready-mixed concrete to site it is needed to retain the workability for longer period. Sometimes the concrete batch does not meet the job requirement when it reaches to the construction site and leads to rejection. [7] This research was focused to find the second dose of SP to regain the original slump for concrete with fly ash. The main objective of this study is to predict the relation between percentage of slump loss and amount of second dose of SP to regain the slump in the concrete with fly ash at site considering water binder ratio, replacement ratio of fly ash and initial SP.

## 2. MATERIALS AND TEST METHODS

### 2.1. Materials

Cement: Ordinary Portland cement Type I was used. The physical and chemical compositions of cement are shown in the table 1

**Table: 1- Chemical/ Physical Properties of Powder and Aggregate Used**

| **Chemical/ Physical Properties of Powder** | | | | | |
|---|---|---|---|---|---|
| Ingredients: | Cement | Fly Ash | Ingredients: | Cement | Fly Ash |
| CaO (%) | 64.28 | 20.01 | $K_2O$ (%) | 0.48 | 2.92 |
| $SiO_2$ (%) | 20.35 | 33.41 | $SO_3$ (%) | 2.92 | 5.19 |
| $Al_2O_3$ (%) | 5.02 | 18.74 | Specific Gravity | 3.1 | 2.24 |
| $Fe_2O_3$ (%) | 3.18 | 15.03 | Blaine Finesse ($cm^2$/gm) | 3440 | 2800 |
| MgO (%) | 2.03 | 2.02 | Loss of Ignition (%) | 1.427 | 0.23 |
| $Na_2O$ (%) | 0.20 | 1.27 | | | |
| **Physical Properties of Aggregate** | | | | | |
| Physical Properties of Aggregate | | | Gravel | Sand | |
| Specific gravity | | | 2.71 | 2.6 | |

| | | | |
|---|---|---|---|
| Fineness modulus | 7.98 | 2.45 | |
| Water absorption (%) | 0.7 | 1.06 | |

Fly Ash: Lignite fly ash conforms to Class 2A, TIS. 2135 from Mae Moh Lignite Power Plant in Lampang Province was used. The physical and chemical composition is as shown in table 1.

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 aggregate. The physical properties of coarse and fine aggregates (gravel and sand) are shown in the table 1.

Chemical Admixture (Superplasticizer): Naphthalene based Superplasticizer (SP) commercially available and widely used in Thailand was used.

### 2.2. Mix Proportion

The concrete mix proportions were made based on the strength class of ready mixed concrete mostly used in Thailand. Mix designed of concrete was with 20% and cement 30% cement replacement by fly ash (FA). For both replacements concrete was prepared for water binder ratio of 0.58, 0.63 and 0.67 respectively. The paste contain of each mix was 1.2.

### 2.3. Concrete Mixing Procedure, Slump Measurement and Re-dosing of Superplasticizer

Drum type concrete mixture was used. Initially binder, course aggregate and fine aggregate were weighted and put in the mixture and dry mixed for one minute. Then weighted amount of water was added and mixed for one minute. Finally weighted amount of superplasticizer was added and mixed for two minutes. Total mixing time was around four minute.

Slump was measured immediately after the mixing procedure was finished and recorded as initial slump. Then concrete was kept in tray with plastic cover to prevent loss of water by evaporation. Then sample of the concrete was used to measure slump value at stipulated time of 30, 60 and 90 minutes respectively. The measured slump was recorded as the slump before re-does. Before measuring slump, the sample was mixed for two minutes to make it homogenous.

Then weighted amount of Superplasticizer was added to the concrete as a second dose and mixed for two minutes to make it homogenous. Again slump was measured and recorded as slump after second dose of superplasticizer. The amount of second dose was varied from 0.1 to 1 % by weight of binder.

The test method described on the ASTM C143-90 was followed to test slump.

### 2.4. Measurement of Compressive Strength

Cylindrical specimens of size 100mm diameter and 200mm length were used to find the compressive strength developed at the age of one , seven and twenty eight days respectively. The test specimens were sealed with a plastic wrap after casting and removing mould after one day. Specimens were cured in water at $28^0$C till the time of testing.

## 3. RESULT AND DISCUSSION

### 3.1. Slump Loss

The figure 1 gives relation between slump losses with time. In this research initial slump was fixed. To make the same initial slump, those mix with lower water binder ratio needed higher initial dose of SP. In stipulated elapsed time, the slump loss was less for those mixes having a higher initial dose of SP and less water binder ratio. The rate of slum loss depends on various factors such as initial slump, type and dose of superplasticizer, ambient temperature, water binder ratio and type of cement and secondary binder. In this case initial slump, ambient temperature, type of cement and type of superplasticizer were same and only different were water binder ration and initial dose of SP. The mechanism responsible for the slump loss involved chemical and physical process. Loss of consistency in cement paste during the dormant stage is mainly attributable to the physical coagulation of cement particles rather than the chemical effect [8]. Since the cement and fly ash particles contains several mineral phases of different reactivity as well as a variety of chemical and structural defects, their initial hydration can generate a surface charge in both magnitude and sign. These localized surface charges promote the early flocculation of hydrating cement particles, but they can be effectively neutralized and superseded by the ionic charge of superplasticizer molecules. The presences of adsorbed SP molecules on the hydrating cement minimize the interaction between particles first through the electrostatic repulsive forces and then steric repulsion. [9] The adsorbed SP molecules not only disturb the hydration of cement but also do not allow the cement and fly ash particles to stick together. This discussion concludes that, higher the initial SP more will be disturbance in the hydration and slower will be the slump loss rate.

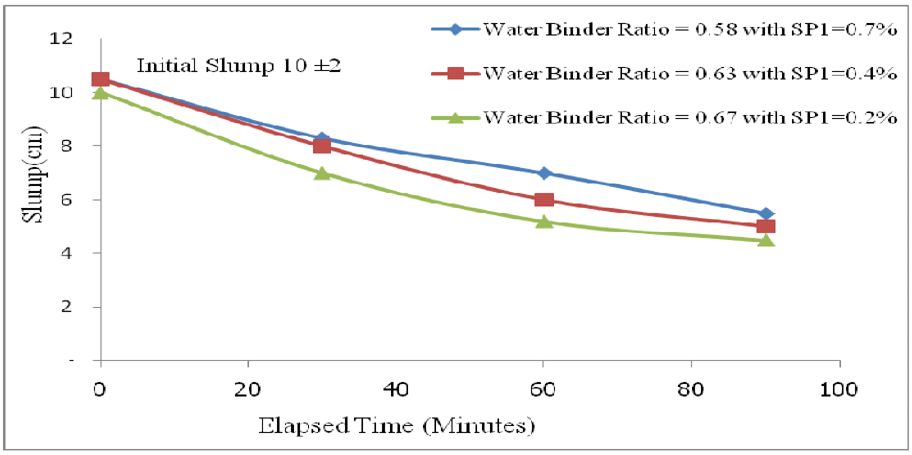


**Figure 1: Relation between initial slump, slump loss and elapsed time with same initial slump and different initial SP and W/B ratio**

### 3.2. Second Dose of Superplasticizer to Regain Original Slump

Figure 2 shows that when superplasticizer was re-dosed the slump was increased. It may be due to; when the superplasticizer is re-dosed zeta potential of binder particles is increased, at the same time viscosity decreased. Increased zeta potentials help to disperse the cement particles and make the concrete more workable and slump is regained. The particle size distribution, micro-shape, surface structure and zeta potential changes are parameters for rheological characterization of cement–powder–superplasticizer dispersion. [10]

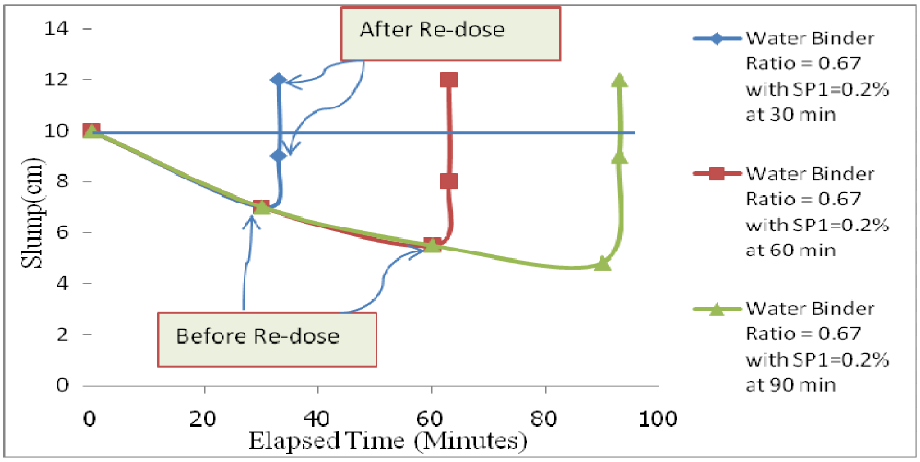


**Figure 2: Relation between initial slump, slump loss, re-dose SP and regain of slump with elapsed time, (Concept of Re-Dose)**

Figure 3 and 4 shows the relation between percentage slump loss and amount of second dose of superplasticizer to regain the original slump with fly ash replacing cement 20% and 30% respectively. The effect of water binder ratio and initial amount of SP were examined while re-dosing of SP. Graph shows that, lower the water binder ratio more will be the second dose of SP to regain the original slump and vice versa, although there is less slump loss for lower water binder ratio.

As initial slump had fixed, to have same initial slump for different water binder ratio, those mix with lower water binder ratio needed higher initial dose of SP. Lower water binder ratio and higher initial dose of SP means there are more binder (cement +FA) particles, less free water and more repulsive fore as compared to the concrete with higher water binder ratio and less initial SP in the same volume of concrete. With the more binder particles, more will be the total specific area of cement. With the elapsed of time, if we add the second dose of SP; concrete with lower w/b ratio will need more SP as there is more specific surface area of cement and less free water.

From the figure 3 and 4 general relation between second dose of SP and percentage slump loss is given by

$$y = ae^{(bx)} \quad (1)$$

Where, **a, b:** constant, y: percentage amount of second dose of SP with the total binder, x: percentage of slump loss with respect to original slump.

The value of constant **b = 0.04** and the value of **'a'** mainly depends on the initial SP and the replacement ratio of fly ash.

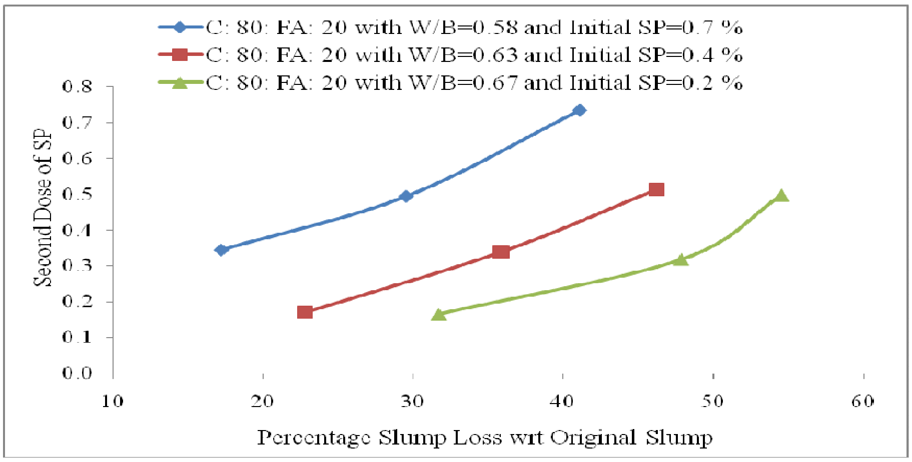


**Figure 3: Relation between Percentage Slump loss and Second Dose of SP with Different Initial SP and W/B Ratio (For FA Replacement 20%)**

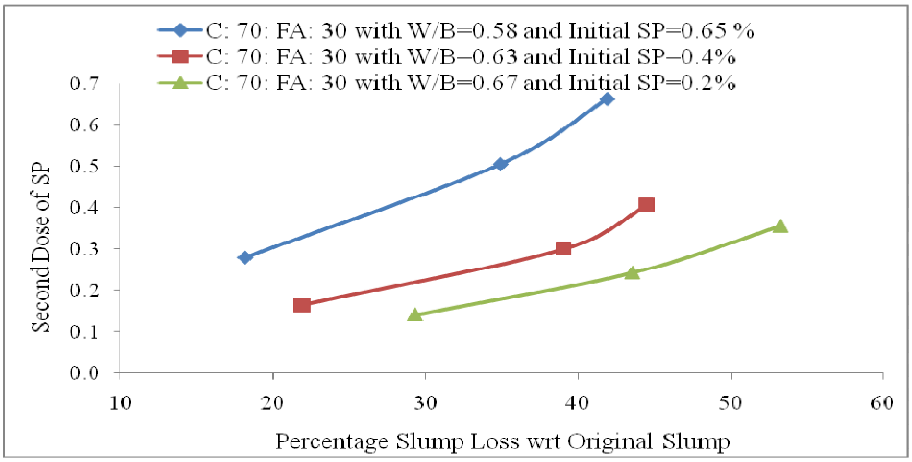


**Figure 4: Relation between Percentage Slump loss and Second Dose of SP with Different Initial SP and W/B Ratio (For FA Replacement 30%**

Figure 5 give the relation between **'a'** and initial SP. It seems that value of 'a' more affected by replacement ratio for lower water binder ratio with higher initial SP. For lower water binder ratio and high initial SP slump is more governed by SP (dispersion) and higher w/b ratio system is more govern by free water. The particle size distribution, micro-shape, surface structure and zeta potential changes are parameters for rheological characterization of cement–powder–superplasticizer dispersion. [11]

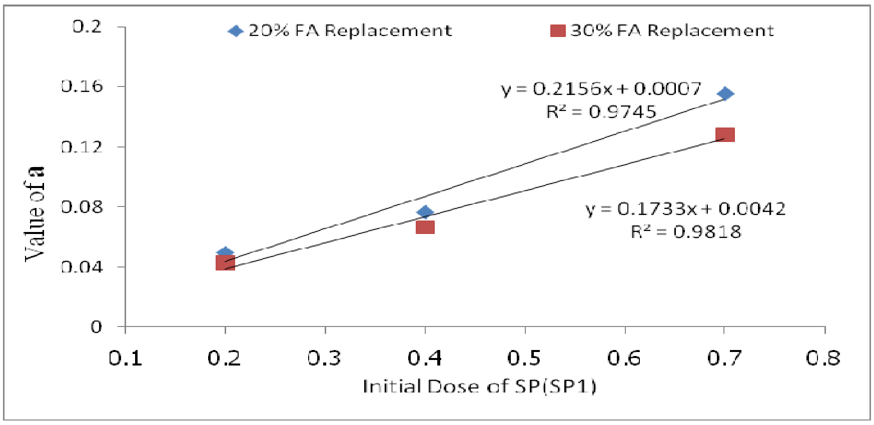


**Figure 5: Relation between value of 'a' and Initial SP**

### 3.3. Effect on Compressive Strength

The table 2 shows the compressive strength of concrete. The compressive strength with and without re-dose was compared for the different water binder ratio and fly ash replacement ratio, and found that there was no significant difference on the compressive strength. But during calculation of second dose of SP we have to be careful about the total dose of SP

**Table: 2- Compressive Strength in 1, 7 and 28 Day with and without Re-dosing**

| C:80:FA:20 with W/C =0.67, Initial SP:0.2% | | | | | C:70:FA:30 with W/C =0.58,Initial SP:0.65% | | | |
|---|---|---|---|---|---|---|---|---|
| S.N | Comp. Strength(MPa) | | | Second Dose of SP2 | Comp. Strength(MPa) | | | Second Dose of SP2 |
| | 1-day | 7-day | 28-day | | 1-day | 7-day | 28-day | |
| 1 | 5.65 | 19.89 | 26.56 | No Second Dose | 10.08 | 19.34 | 31.54 | No Second Dose |
| 2 | 5.76 | 18.48 | 26.01 | 0.60% | 10.35 | 19.36 | 33.62 | 0.20% |
| 4 | 5.02 | 18.28 | 27.75 | 0.10% | 11.24 | 20.52 | 34.18 | 0.80% |
| 5 | 6.38 | 20.13 | 25.79 | 0.20% | 10.43 | 21.95 | 33.33 | 0.60% |
| 6 | 6.59 | 19.26 | 26.61 | 0.40% | 9.99 | 22.00 | 34.11 | 0.30% |

## 4. CONCLUSIONS

From the experimental data it has been concluded that, the second dose of SP basically depend up on initial SP replacement ratio of fly ash. Even same percentage loss of slump, the amount of second dose of SP is more for those mixes having higher initial SP and vice-versa for same initial slump it can be explained intern of water binder ratio as well. There is no any significant effect on the compressive strength due to the addition of second dose of SP.

## ACKNOWLEDGMENTS

Authors would like to thank all team members of Civil Engineering Laboratory, SIIT and all members of CONTEC, SIIT for their valuable suggestion and help during the experiment time.

Authors would also like to thank for and Asian Development Bank for financial support of this research work as thesis allowance.

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