

# Workability Loss of Superplasticized Concrete

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## ABSTRACT

One of the main problems facing the superplasticized concrete is the loss of workability with time, which is affected by a number of factors. In the present research, the results of an experimental study investigated the influence of the main factors on the loss of workability are presented. The factors considered in the present study related to the superplasticizer, its dosage and the time for addition to mixtures, and the properties of the concrete mixture, the w/c ratio and the type of coarse aggregate.

Over a period of 60 min after mixing, the loss of workability was measured for 24 different concrete mixtures, where the loss of workability was expressed in terms of slump loss and compacting factor loss. For each concrete mixture, the slump measurement was carried out after 2, 15, 30, 45 and 60 min and the compacting factor was determined after 2, 30 and 60 min.

## KEY WORDS:

Workability, Superplasticizer, Slump, Compacting factor, Coarse aggregate, w/c ratio

## 1. INTRODUCTION

The use of superplasticizers evokes changes in the characteristics of fresh concrete, making it more liquid. These changes result from increasing cement dispersion in concrete paste, which facilitates the release of water by reducing the adsorptive and capillary forces within the cement paste<sup>(1)</sup>. The workability improvement of concrete mixes by using superplasticizer is of short duration and within 30 to 60 min the concrete

reverts to its original consistency. The rapid loss of workability of superplasticized concrete with time is a serious disadvantages and research is being continued to find a solution to this problem. A number of factors affect on the loss of workability of superplasticized concrete. In addition to the properties of the constituent materials and the compatibility between them, the mixing procedure has also proved to be important, in particular the time for addition of the superplasticizing admixture. The amount of superplasticizer is also an important factor, which significantly affects the total surface of solid particles in the particle system.

There are many methods describing the workability properties of fresh concrete, the most conventional way to express the loss of workability is slump loss. In this research compacting factor test is also used to measure the loss of workability.

The purpose of the current research is to determine the influence of mixing procedure and amount of superplasticizer on the workability loss of concrete when applied superplasticizers to concrete mixes of different types of coarse aggregate and w/c ratios. The loss of workability is described in terms of slump loss and compacting factor loss.

## **2. EXPERIMENTAL TEST PROGRAM**

The experimental program included three different test series based on 24 concrete mixes (Table 1). In the first and second test series, three different mixing procedures were included. The different between the two test series was the w/c ratio, where it was 0.5 for the first series and 0.4 for the second series. In the third test series, the amount of superplasticizer was varied from 1.5 to 2.0 and 2.5 percent by weight of cement, and the water content was adjusted to give the same initial slump. In all series, three types of coarse aggregates; gravel, crushed dolomite and crushed basalt were used.

In mixing procedure A, all water and superplasticizer were added in the beginning of the mixing together with aggregate and cement. In procedure B, the addition of superplasticizer in combination with one-third of the mixing water was delayed by 1.5 min. In procedure C, one half of the superplasticizer and 20 percent of water were delayed by 3.0 min. Figure1 illustrates the different mixing procedures used.

After mixing, slump measurements were carried out after 2, 15, 30, 45, and 60 min. In addition, compacting factor were determined at 2, 30, and 60 min after mixing. Before each testing, the fresh concrete was remixed for 30 sec.

### 3. MATERIALS

The materials used for making the concrete mixtures were Ordinary Portland cement, a natural sand with 2.65 fineness modulus, high-range water-reduction admixture (superplasticizer) has a trade name ADDICRETE BVF, and three types of coarse aggregates.

One aggregate consisted of round and smooth particles of gravel; the other two consisted of crushed particles with rough surface of dolomite and basalt. The maximum size of all coarse aggregate types was 5/8 inch (15.8 mm). Particles of all aggregates appeared to be clean, hard, and strong.

For each concrete mix, three cubes (15 x 15 x 15 cm) were prepared for standard testing of compressive strength. Table 1 shows the mix proportions and compressive strength of concrete mixtures.

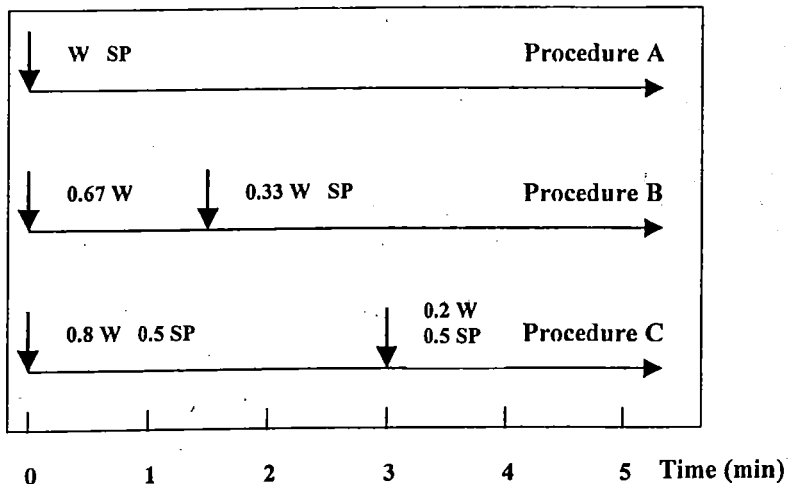


Fig.1. Different Mixing Procedures Used

(W = water; SP = Superplasticizer)

Table 1. Test Program, Mix Proportions and Compressive Strength

Test Series		Mixing procedure, w/c =0.5										Mixing procedure, w/c =0.4							
Mix No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mixing Procedure		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Type of coarse aggregate		Gravel			Dolomite			Basalt			Gravel			Dolomite			Basalt		
Superplasticizer, percent		2.0																	
W/c ratio		0.5																	
Aggregate, Kg		1875			1850			1900			1950			1925			1975		
Compressive strength, Kg/m <sup>2</sup>		265	273	278	287	280	289	282	275	281	334	342	346	363	369	372	373	365	377
Test Series		Superplasticizer dosage																	
Mix No.		19	3	20	21	6	22	23	9	24									
Mixing Procedure		C																	
Type of coarse aggregate		Gravel			Dolomite			Basalt											
Superplasticizer, percent		1.5	2	2.5	1.5	2	2.5	1.5	2	2.5									
W/c ratio		0.53	0.5	0.47	0.53	0.5	0.47	0.53	0.5	0.47									
Aggregate, Kg		1850	1875	1900	1825	1850	1875	1875	1900	1925									
Compressive strength, Kg/m <sup>2</sup>		261	278	291	272	289	310	269	281	298									

For all Concrete Mixtures:  
— Cement content = 350 Kg/m<sup>2</sup>  
— Sand : Coarse aggregate = 1:2

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## 4. RESULTS AND DISCUSSION

The results from the 24 concrete mixtures are presented in Figures 2-7. These results will be discussed in the following items:

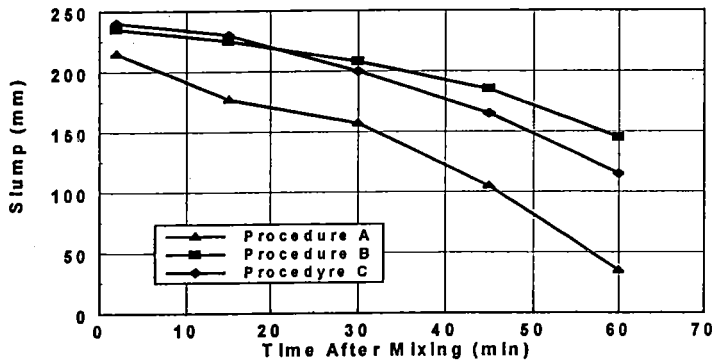
### 4.1 Effect of Mixing Procedure

The phenomenon of workability loss is normally assumed to be associated with the adsorption of admixture by the hydrated phases<sup>(3)</sup>. It was observed that maximum workability measured by minislump was obtained when the admixture was added at the beginning of the dormant period of the cement hydration<sup>(6)</sup>.

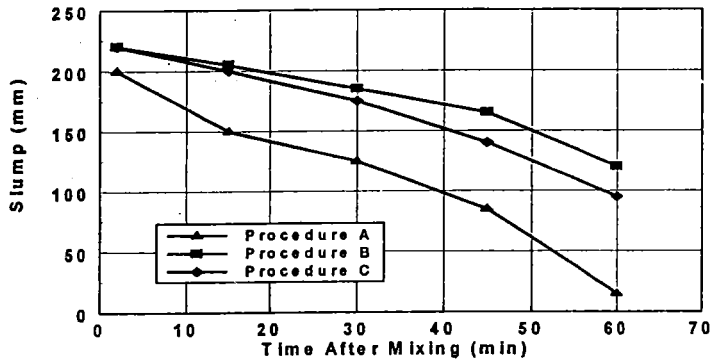
From figures 2-5 it can be seen that during the first 30 min the slump was not much affected apart from in mixing procedure A, where the superplasticizer was added with the mixing water. For this immediate addition, during a period 60 min the slump loss was 180 mm for w/c ratio 0.5 and 165 mm for w/c ratio 0.4, and the compacting factor was reduced by 12% for w/c ratio 0.5 and 10% for w/c ratio 0.4. After 30 min, the lowest slump was observed for mixing procedure B, where the addition of superplasticizer had been delayed by 1.5 min. for this mixing procedure, the slump was reduced, over a period 60 min, by 95 mm for w/c ratio 0.5 and 75 mm for w/c ratio 0.4, and the loss of compacting factor was 5.5% for w/c ratio 0.5 and 3.5% for w/c ratio 0.4. For mixing procedure C, where the addition of superplasticizer had been partly delayed by 3 min, the slump loss during a period 60 min was 120 mm for w/c ratio 0.5 and 100 mm for w/c ratio 0.4 and the compacting factor was reduced by 7.5% for w/c ratio 0.5 and 5% for w/c ratio 0.4.

It can be concluded that the mixing procedure had significant effect on the workability loss. Comparing with adding superplasticizer with mixing water, delaying the addition of superplasticizer by 1.5 min reduced the workability loss by about 50% and partly delaying the addition of superplasticizer by 3 min reduced the workability loss by about 65%.

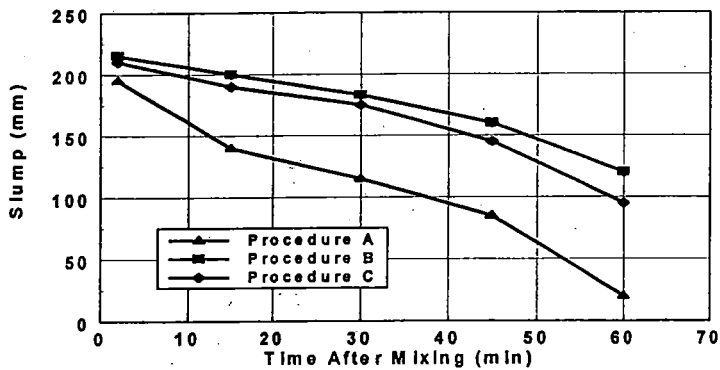
As can be seen from table 1, the different mixing procedures did not affect the compressive strength.



a) Gravel

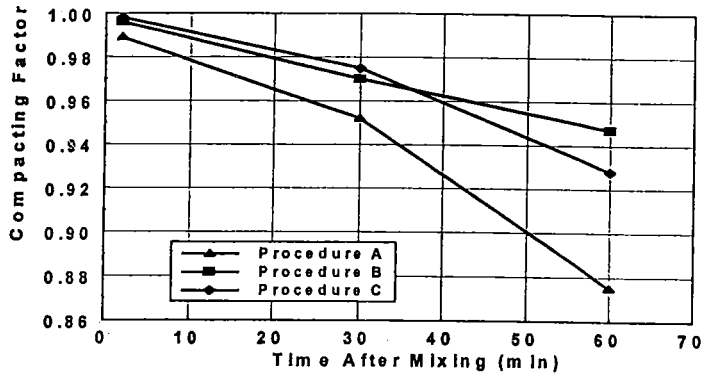


b) Crushed Dolomite

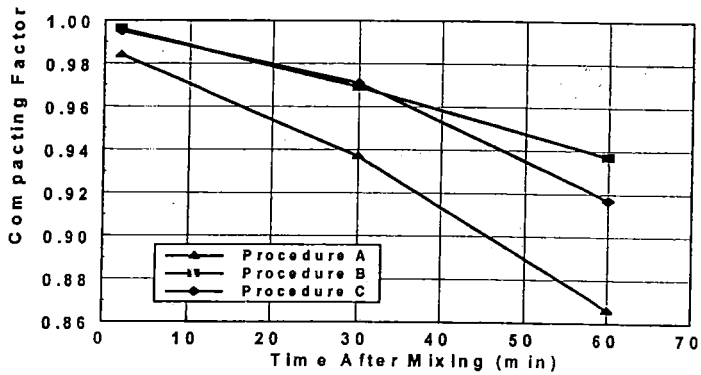


c) Crushed Basalt

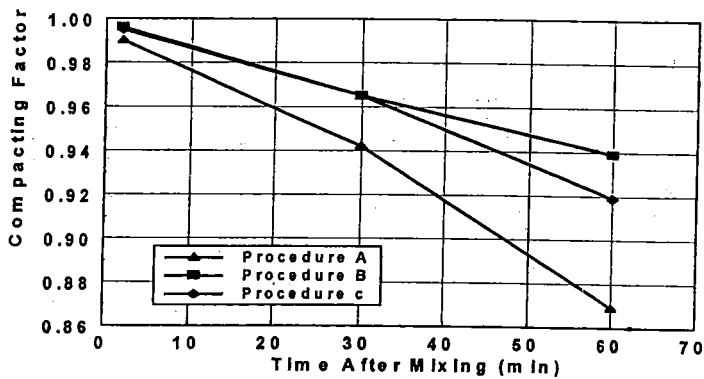
Fig.2. Effect of Mixing Procedure on Slump Loss for Different Types of Coarse Aggregate and  $w/c = 0.5$



a) Gravel

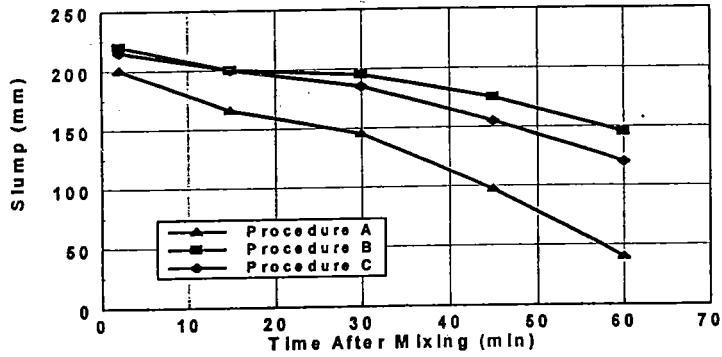


b) Crushed Dolomite

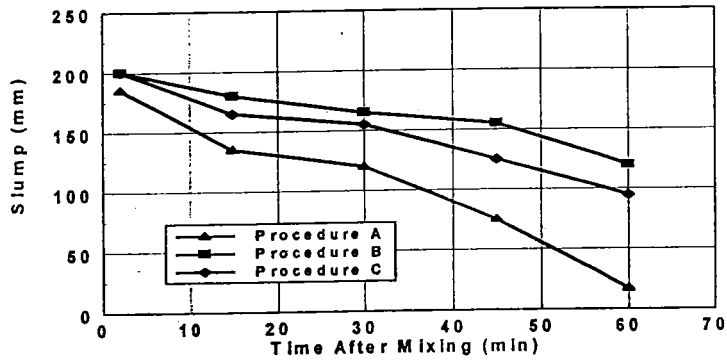


c) Crushed Basalt

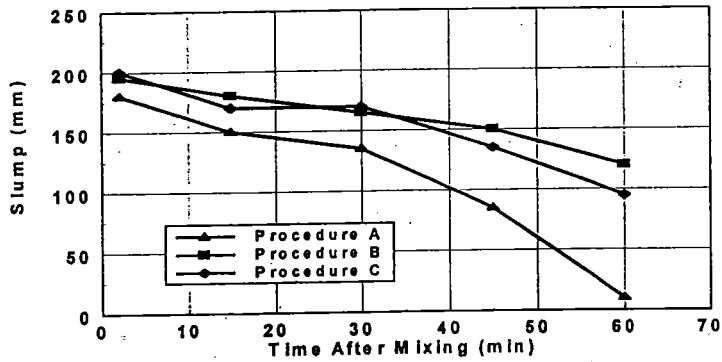
Fig.3. Effect of Mixing Procedure on Compacting Factor Loss for Different Types of Coarse Aggregate and  $w/c = 0.5$



a) Gravel



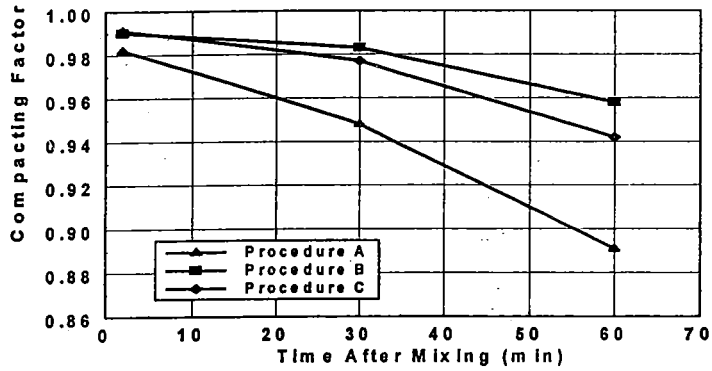
b) Crushed Dolomite



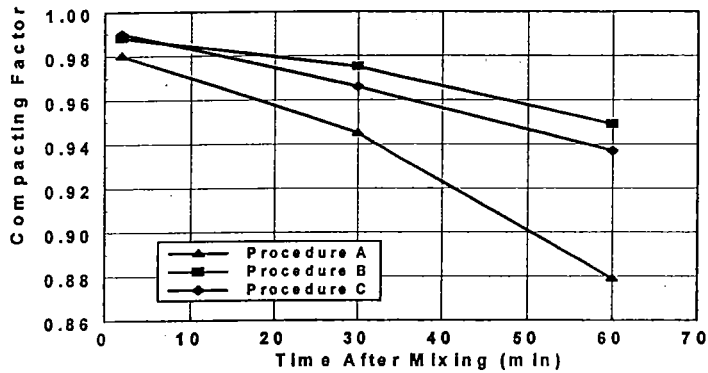
c) Crushed Basalt

Fig.4. Effect of Mixing Procedure on Slump Loss for Different Types of Coarse Aggregate and  $w/c = 0.4$

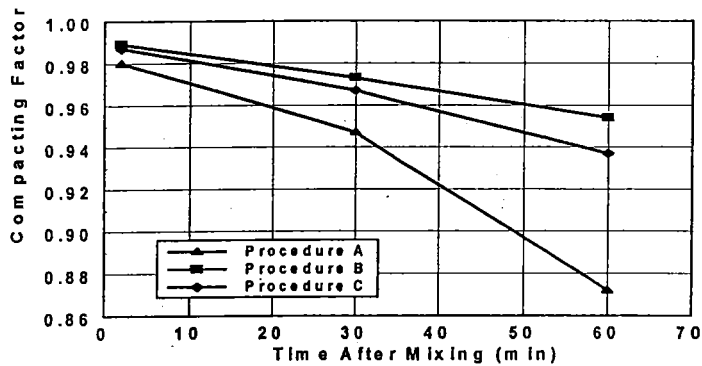




a) Gravel



b) Crushed Dolomite



c) Crushed Basalt

Fig.5. Effect of Mixing Procedure on Compacting Factor Loss for Different Types of Coarse Aggregate and  $w/c = 0.4$

#### 4.2. Effect of Superplasticizer

Figures 6 and 7 demonstrate that a change in dosage of superplasticizer with keeping the initial slump constant had a distinct effect on the workability properties.

As can be seen from Figures 6 and 7, the concrete mixes with 2 and 2.5 percent superplasticizer had about the same workability loss, where the slump reduced, over a period 60 min, by 120 mm for 2% dosage and 110 mm for 2.5% dosage, and the loss of compacting factor was 7.5% for 2% dosage and 5.5% for 2.5% dosage. While the 1.5 percent dosage showed a slump loss as high as 180 mm and a compacting factor loss 12%.

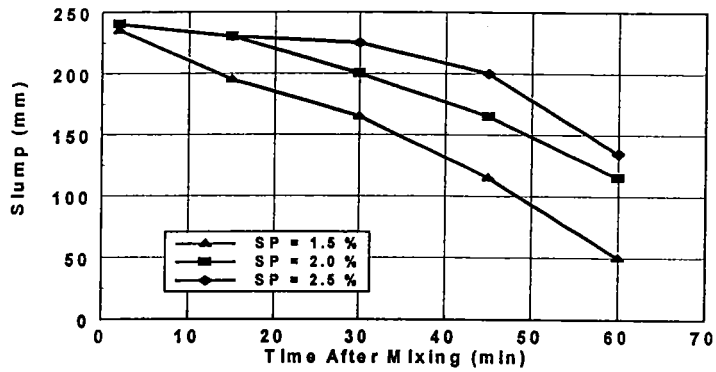
Based upon above, it can be concluded that increasing the dosage of superplasticizer reduces the workability loss to a certain saturation level for the superplasticizer, above which only a small effect on the workability loss is obtained.

#### 4.3. Effect of Coarse Aggregate

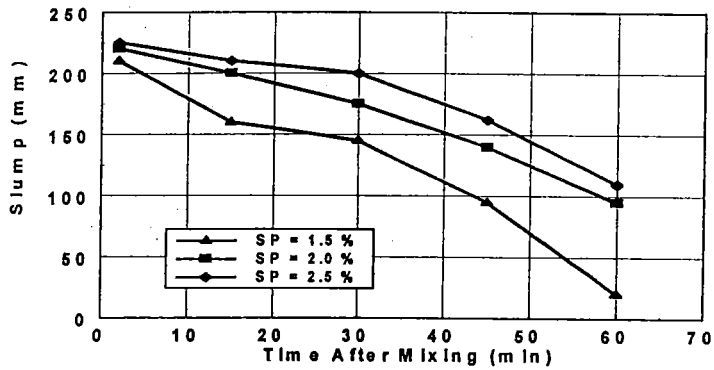
The particle shape and surface texture of the coarse aggregate influence the properties of freshly mixed concrete more than the properties of hardened concrete, where the use of round coarse aggregate results in an increase in effective w/c ratio of the concrete mix and decreases the particle interface.

Figures 2-7 show that the changing of the coarse aggregate from gravel to crushed dolomite or crushed basalt reduced the initial slump in the range from 15 to 20 mm, and that changing of coarse aggregate had negligible effect on the loss of workability.

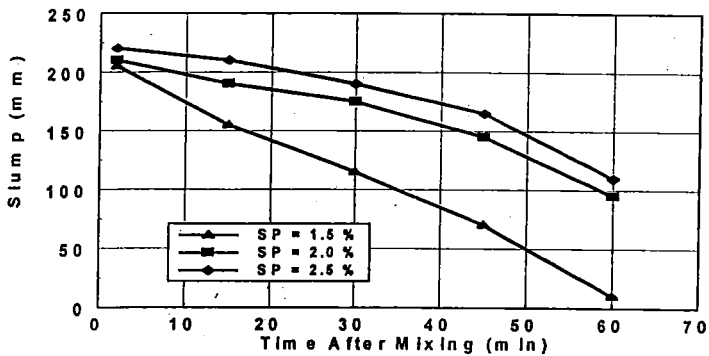
This effect of coarse aggregate on the workability can be referred to that the initial superplasticizing effect is a physical one, which affects with the type of coarse aggregate, and is then subject to a chemical interaction between cement paste and superplasticizer.



a) Gravel

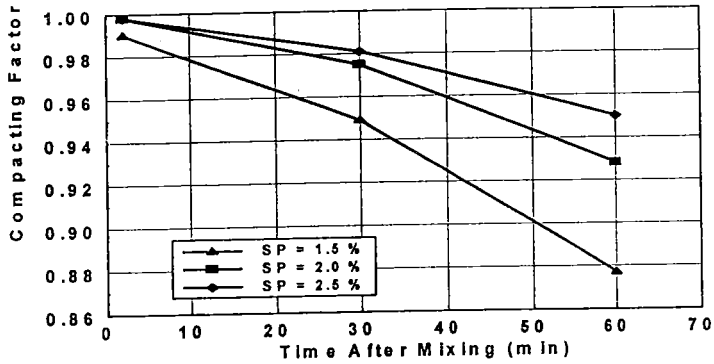


b) Crushed Dolomite

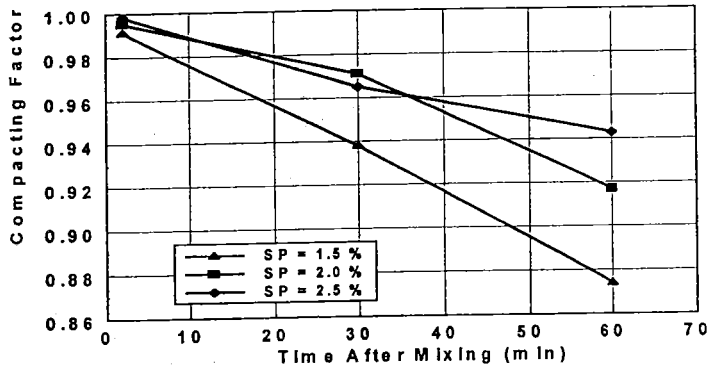


c) Crushed Basalt

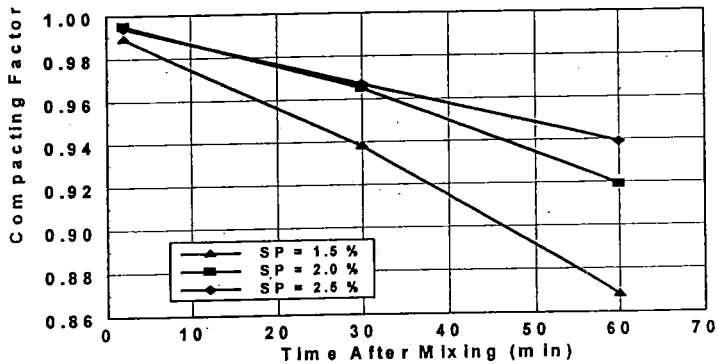
Fig.6. Effect of Superplasticizer Dosage on Slump Loss for Different Types of Coarse Aggregate



a) Gravel



b) Crushed Dolomite



c) Crushed Basalt

Fig.7. Effect of Superplasticizer Dosage on Compacting Factor Loss for Different Types of Coarse Aggregate

#### 4.4. Effect of W/C Ratio

As can be seen from Figures 2-5, the w/c ratio had an effect on both the initial workability properties and the loss of workability.

From Figures 2-5, it can be seen that decreasing the w/c ratio from 0.5 to 0.4 reduced the initial slump for different concrete mixtures in the range from 15 to 25 mm. And that decreasing of w/c ratio had also an effect on the workability loss for different mixing procedures, as illustrated in item 1-4.

As would be expected when the w/c ratio decreased, for the same superplasticizer dosage, the initial workability decreased. But decreasing w/c ratio also decreased the loss of workability especially for mixing procedure B and C, where the addition of superplasticizer had been delayed by 1.5 min and partly 3 min, respectively

#### 5. CONCLUSIONS

The mechanism for workability loss of superplasticized concrete is rather complex, and a number of factors are involved. According to the variables taken into consideration in the present experimental investigation, the following conclusions can be drawn:

1. The workability loss was not greatly affected by the mixing procedure during the first 30 min from the beginning of the mixing.
2. Delaying in the addition of superplasticizer had a distinct effect on reducing the workability loss; short delay (1.5 min) was more effective than longer partly delay (3.0 min).
3. An increasing amount of superplasticiaer reduced the loss of workability. A higher dosage more than 2 percent caused a small reduce in the workability loss, which mean that there is an optimal dosage has a distinct effect on the workability loss.
4. The lower the w/c ratio; the more effective was the superplasticizer in reducing the workability loss when applied at a constant dosage.
5. Type of coarse aggregate affected on the initial workability properties, gravel increased workability more than crushed dolomite or crushed basalt, while the workability loss was not affected.

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