ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 3, No. 3, November 2012

INVESTIGATION OF THE CHEMICAL ADMIXTURE INFLUENCE ON THE PERFORMANCE OF SELF COMPACTING CONCRETE

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ABSTRACT

A new formulation approach by using fines material supported by development of chemical admixture open the way to amazing progresses in concrete technology. The range of perfomances and characteristics that are covered by concrete have been expended in two way directions from conventional concrete to self compacting concrete (SCC). In order to establish an admixture system which can fulfil the SCC requirements, the mixes contained either a small quantity of fly ash (20%) or none. The aim of the research is to evaluate and invertigate the use of chemical admixture in SCC mixes that influent the properties of hardening concrete. Three different chemical admixture were used in the research. Decreasing the water-cement powder ratio may negatively influence the flowing ability of fresh concrete. Special attention must be paid to add of mineral admixtures, like fly ash are often used to modify the microstructure of the concrete matrix and to optimise the transition zone. The reduction of water-cement powder ratio in a decrease in porosity and increase the performance hardening concrete. In this research water to cement ratio around 0.28. The results shown that the lowest value of water-cement ratio the higher use of chemical admixture and increase the compressive strength of SCC (MixCA3).

Keywords: Self compacting concrete (SCC), mineral admixture, chemical admixture, performance of SCC. introduction, context and review of literature, method, findings, discussion and conclusion.

INTRODUCTION

Self-Compacting Concrete (SCC) was first introduced in the late 1980's by Japanese researchers, in order to reach durable concrete structures. Since then, some research and investigations have been carried out to achieve a rational SCC mix design. SCC is defined so that can flow under its own weight and does not require any internal and external vibration for compaction without segregation and bleeding, and completely fills the formwork and the spaces between the reinforcement (Okamura, 1999). SCC flows and has nearly a horizontal concrete level after placing.

SCC consists of the same components as conventional concrete, which are cement, aggregates (course and fine aggregates), water, mineral additives (such as fly ash) and chemical additives (admixtures). However, the high amount of admixture (superplasticizer) for reduction of the liquid limit and for better workability, the high powder fuctioning to lubricant the coarse aggregates, as well as the use of viscosity-agents to increase the viscosity of the concrete have to be taken into account.

For SCC, it is generally necessary to use superplasticizers in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation and bleeding. The powdered materials that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler, etc. In principle, the properties of the fresh and hardened SCC, which depend on the mix design, should not be different from conventional concrete. One exception is only the consistency. Self-compacting concrete should have a slump flow more than 65 cm after pulling the flow cone. In general, SCC provides some advantages compare to those coventional concrete.

1. Sample placement in complicated formwork tight reinforcement.

2. Reduced construction time, specially at large construction sites (caused of no compaction work needed).
3. Reduced noise pollution (due to the noise of vibrated equipment)
4. Less workers needs.
5. Improve concrete surfaces and finishes.

MATERIALS AND METHOD

Materials used in the research were Pordland Pozzolan Cement (PPC), course aggregates obtained from crush stone factory in Pasuruan, East Java, Indonesia. Fine aggregates obtained from Lumajang, East Java, Indonesia, fly ash obtained from plant 5 and 7 Paiton, East Java, Indonesia. The chemical properties of fly ash are given in the Table 1.

The paste is optimized first, then the mortar and finally the concrete. The requisite levels of water and superplasticizer are established in the paste and mortar tests (Okamura, 1999). The water content needed to wet the surfaces of the solid particles and fill the voids in the particulate powder material represents the minimum quantity of mixing water that has to be provided. Above this water content the properties of the suspension can be controlled by water and superplasticizer. The final optimization is then carried out in concrete tests.

Mix Design

In designing a concrete mix for SCC, the following requirements were proposed in this research:

1. Cement used Portland Pozzolan Cement (PPC)
2. Coarse aggregate (< 9.6 mm) equal to 50% by weight of total aggregate.
3. Fine aggregate (from 0.125 – 4 mm) equal to 50% by weight of total aggregate.
4. Superplasticisers type 1 until type 3 around 1.0 to 3.0 litres/100 kg cement (high workability and high strength) (EFNARC, 2005)
5. Cementitious content 0 - 375 Kg/m^3
6. Water content 150 -200 litres/m^3.

Table 1. The chemical properties of fly ash

Parameter	Unit	Test Results	Methode Test
Silicon dioxide (SiO_2)	%	65.88	Gravimetry
Alumunium Oxide (Al_2O_3)	%	4.27	Spektrophotometry
Iron Oxide (Fe_2O_3)	%	6.86	AAS
Calsium Oxide (CaO)	%	9.82	Titrimetry
Magnesium Oxide (MgO)	%	6.74	Titrimetry
Sodium dioxide (Na_2O)	%	0.92	Flamephotometry
Kalium dioxide (K_2O)	%	0.48	Flamephotometry
Sulfur trioxide (SO_3)	%	0.54	Spektrophotometry
Phosphate as (P_2O_5)	%	1.35	Spektrophotometry
Titanium Dioxide (TiO_2)	%	0.12	Spektrophotometry
Los Of Ignetion (LOI)	%	2.21	Gravimetry\

The method used to determine the proportions was different for the conventional concrete and the SCC mixtures. The SCC mixtures were proportioned according to the mixture design that uses the approach of using sufficient fine particles to achieve viscosity. Superplasticisers were used in the SCC mixture during this study. Laboratory tests shall be carried out to determine the mixes of the available

ISSN-L: 2223-9553, ISSN: 2223-9944
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materials. In this project, trial mixes were tested to determine the following fresh and hardened properties. Detail of optimum mix design is presented in Table 2.

Fresh Concrete Properties

The slump test is the quality control test for the conventional concrete mixtures. The slump flow was used to determine if the SCC mixtures in this project were acceptable. Although the slump flow, L-box, and V-funnel do not have much significance with the conventional concretes, they were performed in order to compare with the SCC mixtures (Jin *et al.,* 2002). The same can be stated about the slump test for SCC mixtures. Slump flow is currently one of the most commonly used SCC tests.

Table 2. The composition of SCC mixes

Ingredient	Mix CA1	Mix CA2	Mix CA3
Portland Pozzolant Cement, kg/m^3	520	520	520
Fine Aggregate, kg/m^3	875	875	875
Course Aggregate, kg/m^3 :			
→Ø9.5 mm	131	131	131
→Ø6.3 mm	525	525	525
→Ø4.75 mm	219	219	219
Fly ash, lt/m^3	130	130	130
Chemical Admixture 1 (CA1), lt/m^3	6.63	-	-
Chemical Admixture 2 (CA2), lt/m^3	-	7.37	-
Chemical Admixture 3 (CA3), lt/m^3	-	-	7.5
Water, lt/m^3	183.3	169	163.8

Hardened Concrete Properties

In general, higher strengths result in flowing concretes containing superplasticizers than in concretes of the same mix proportions that contain no admixture (Esping *et al.,* 2006). During the time that the fresh tests were being performed, 150 x 300 cylinders were prepared for determining properties of the hardened concrete. 14 cylinders were made from each mixture in order to test three samples (cylinders) of concrete at ages of 3, 7, 21, and 28 days. The compressive strength result was taken as the mean of the three cylinders. In this research, it was assumed that if the range of individual strengths of specimens made from the same sample exceeded 15% of the mean then the method of making, during and testing specimens shall be checked and new modified specimens should be tested.

RESULTS AND DISCUSSION

Self-compacting concrete by the name itself suggests that the fresh concrete has the ability to flow under its own weight and settle. Results of the fresh concrete propeties of SCC shown in Table 3. A summary of the 3, 7, 21, and 28-day compressive strengths for the all mixes of SCC is given in figure1-7.

Table 3. The properties of fresh concrete of SCC

Test Methods	Unit	Standars	Lab Results	Remark
Slump flow	mm	650 - 800	715	OK
V- funnel	sec	6 - 12	7	OK
L-box Shape	h_2/h_1	0.8 - 1	0.9	OK

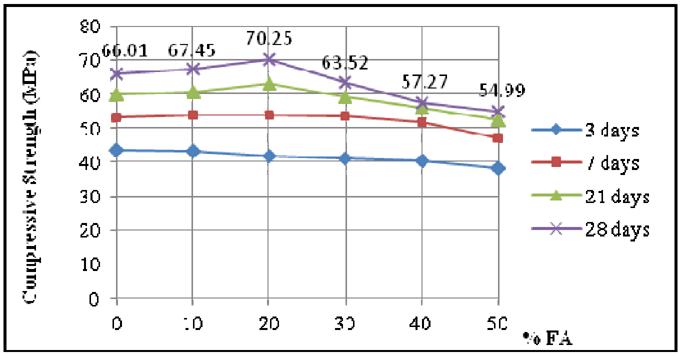

Figure 1. Compressive strength vs percent of FA of MixCA1

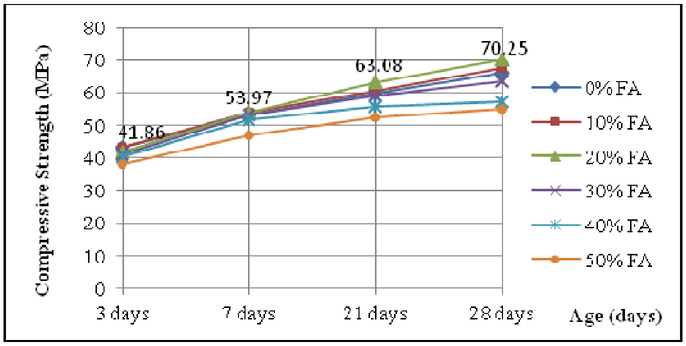

Figure 2. Compressive strength vs the period of curing of MixCA1

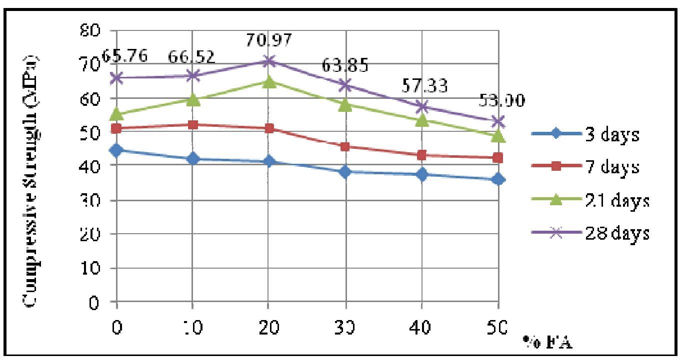

Figure 3. Compressive strength vs percent of FA of MixCA2

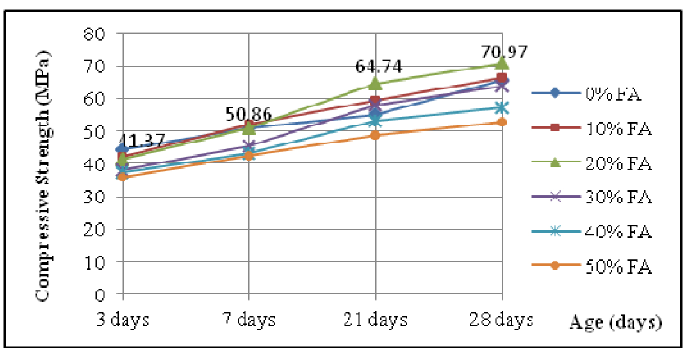

Figure 4. Compressive strength vs the period of curing of MixCA2

ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 3, No. 3, November 2012

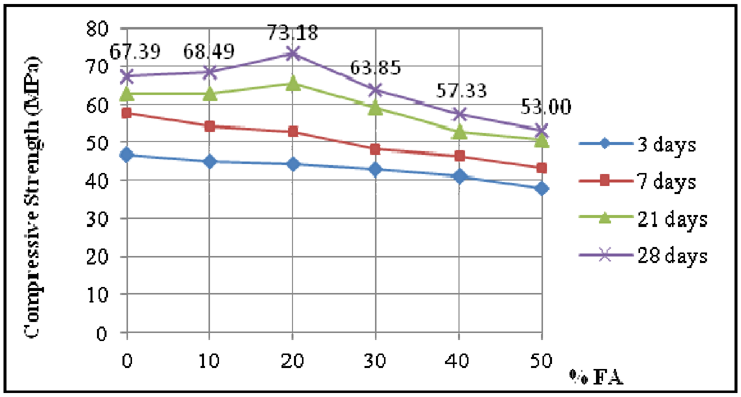

Figure 5. Compressive strength vs percent of FA of MixCA3

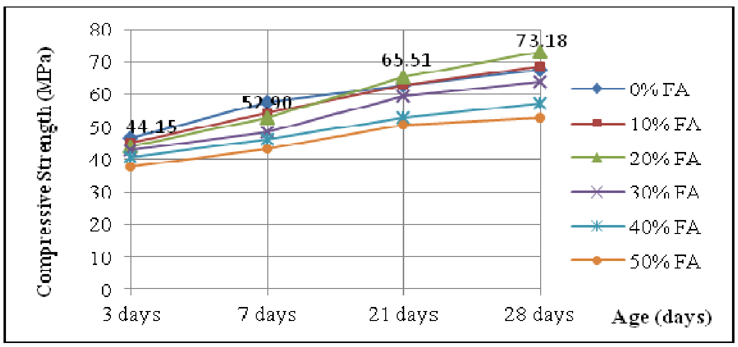

Figure 6. Compressive strength vs the period of curing of MixCA3

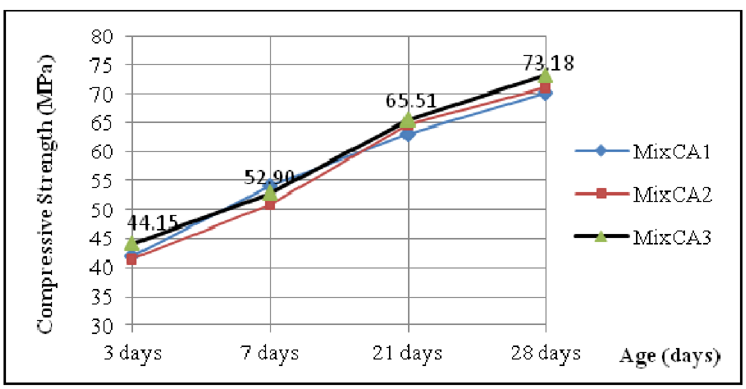

Figure 7. Compressive strength of three mixes of SCC

The basic components of the mix composition of SCC are the same as in conventional concrete. However, to obtain the required properties of fresh concrete in SCC, a higher proportion of mineral admixtures and the incorporation of chemical admixtures are necessary.

Noticeable is the high early compressive strength of the SCC due to the use of 20 percent fly ash. Such concrete types normally have a slower strength development because of the lower hydration rate of the fly ash.

The relationship between water-cement ratio and 28-day compressive strength of concrete as given in *Fig* 7 need extrapolation of curves for higher grades of concrete, because the target 28-day compressive strengths of concrete will be higher for these grades.

CONCLUSION

This paper has demonstrated the potential of workability concept as a powerful tool to improve the quality control of exciting new material, that is SCC. The use of SCC is in constant growth in all developed countries.

The following is some of the conclusions arrived at in this research:

1. The compressive strength of concrete increase depends on the dosage of the superplasticizer. The more of use the superplasticizer the higher of compressive strength.
2. Percent of water-cement material ratio. The smaller the percent of water-cement material ratio the the better the result (Mix CA3).
3. Amount of cement and aggregate (course and fine aggregate). The more fine aggregate consist in mix concrete the better the result.
4. Amount of fines material use, such as fly ash. With 20 percent fly ash as cementitious material is the optimum performance of SCC.
5. Laboratory trials should be used to verify properties of the initial mix composition.
6. The relative fluidity values depend on factors such as the chemical and mineralogical admixture.
7. The slump values are also influenced by the cement content of the concrete, increasing with cement content.
8. During production of SCC, tests of aggregate grading and moisture content should be carried out more frequently than usual, since SCC is more sensitive than conventional concrete to variations.
9. Quality control is important when using SCC.
10. A criterion for accepting self-compacting concrete would be a maximum aggregate size of up to 9.5 mm.

ACKNOWLEDGEMENT

The authors thank for the financing grant by the Ministry of Education and Culture in Project "Model and Aplication of Artificial Neural Networks (ANNs) in Predicting the High Strength of SCC with Fly Ash as Cementitious Material" developed in the Civil Engineering Laboratory.

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