BONDING STRENGTH CHARACTERISTIC OF SELF COMPACTING CONCRETE INCORPORATING FLY ASH

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ABSTRACT: The choice of Self Compacting Concrete (SCC) is because of high workability of this new material. SCC has been developed for several years to achieve more capability and more performance in term of strength, rheology and durability. In spite of compressive strength and other properties, bonding strength characteristic of SCC is much less understood, especially SCC incorporating fly ash. Malaysia country produces plenty of fly ash as waste material which can influence to the natural conservation. Using fly ash as waste materials as replacement of cement in SCC can reduce significantly of fly ash, so using fly ash is big concern of environmental safety and nature conservation. Pull out test was done to know the capability of bonding strength of this material. The water binder ratio appears to govern the bonding strength capacity.

Keywords: SCC, PFA, High Performance, and bonding strength.

11. INTRODUCTION

Concrete has been developed in various types. One of development is self compacting concrete. Self compacting concrete was started by developing for pre-cast structural components comprising of congested steel reinforcement, which may cause difficulties in compaction by means of vibration. The self compatibility is usually achieved by adding a certain amount of very fine material i.e. fly ash or any other such material as filler together with viscosity modifying agent able to keep fresh concrete viscous enough to avoid bleeding and segregation. So far majority of contemporary research a SCC was remained focused on rheological properties and basic engineering properties such as compressive strength, flexural strength etc.

Self Compacting Concrete (SCC) is relatively new material which aims to produce effective concrete pouring into concrete formwork. SCC can shortcut construction time because this material ability to flow fast in formwork shortage skill labor and. High fluidity and segregation resistance is obtained by using superplastizer. The ability of fluidity is very useful especially in pre-cast industry that contain very congested steel bar.

In addition supplementary filler materials these are usually inert in nature such as lime stare powder, natural pozzolans, Pulverized Fuel Ash (PFA) is also introduced to increase the viscosity and reduce the cost of concrete, and therefore, there is a possibility of introducing some locally available filler materials that can enhance the viscosity by reducing the cost.

1. PROBLEM STATEMENT

The development of SCC is mainly focused for pre-cast industry manufacturing of large size bridge girders, which are usually composed of very congested steel reinforcement details. By using of SCC can make it possible in term of cost and effective compaction with reducing the cement that be replaced by waste product like PFA. Strength and performance is very crucial to be investigated especially bonding behaviour of SCC contain PFA.

2. OBJECTIVE OF STUDY

In order to avoid the perceived problems related to the concrete of behavior of SCC under static loads, following are the principal objectives of this research: to determine the optimum mix design of SCC using fly ash from local source, the optimum mix design can produce highly durable harden concrete, to determine of bonding characteristic of SCC contain PFA.

3. BACKGROUND

SELF COMPACTING CONCRETE

Japan is pioneer of SCC as in bridge, building and tunnel construction. In the United States, the application of SCC in highway bridge construction is limited. However, the U.S. precast concrete industry is beginning to accept the technology for architectural concrete. SCC has high potential for wider structural applications in highway bridge construction.[1,2]

This type of concrete which no need to be vibrated is a challenge to the building industry. In order to achieve such behavior, the fresh concrete must show both high fluidity and good cohesiveness at the same time. [2]

Self-compacting concrete (SCC) base on many researches can be defined as a concrete which has little resistance to flow so that it can be placed and compacted under its own weight [3].

SCC recipes are often associated with high contents of binder, fillers and plasticizer admixtures, which all may contribute to increased drying shrinkage. It is understood that the improvement of superplasticizers is another major breakthrough which will have a significant effect on the production and use of concrete in years to come.[4]

MIX DESIGN

The viscosity or rheology of self-compacting concrete mixtures is greatly influenced by their powder content. Higher content of cement can cause thermal cracking in structures. So it is a common practice to use significant amounts of mineral admixtures, such as fly ash, ground granulated blast-furnace slag, or limestone powder. Using the limestone product in mass uses was reported by Nagataki (1998), reported that 290,000 m^3 of a selfcompacting concrete mixture, containing 150 kg/m3 limestone powder and a superplasticizing admixture, were used for the construction of the two anchorage structure of the Akashi-Kaikyo Bridge system in Japan, so this material can be used to replace cement. This anchorage structure consisted of densely-arranged reinforcement and cable frame congested with steel. In another application, high-fluidity concrete with extremely low w/cm was used for bottom up using pipe concreting of a concrete-filled steel column without compaction.[4,5]

The method to achieve self-compact ability involves not only high deformability of cement, but also avoid to segregation between aggregates and mortar when the concrete flows through the confined zone of reinforcement bars.[6]
High-strength concrete was first used in structure system in reinforced concrete frame buildings with 30 or more stories. Commonly in tall buildings, the size of columns in the lower one-third part of the building is rather large when conventional concrete is used. Concrete building system can save cost and the other hand the choice of reinforced concrete frame instead of steel frame in high-rise buildings permits additional savings resulting from higher construction speeds. Uses of SCC will increase this advantage.[4]

There is correlation between rheological properties to strength in SCC. Also Nguyen (2006) made investigation correlation with L-box and rheological properties. Stefan and Horst (investigated effects of small deviations in the water addition on the initial flow behaviour [1]

Fly ash has long been used as a PC additive or as an active addition in concrete, due to economic and technological benefits. [7,8]

POZOLAN

Alkali Silica Reaction can be defined as chemical reactions between aggregates containing certain reactive constituents and alkalis and hydroxyl ions released by the hydration of cement can have a deleterious effect on concrete. When the aggregates in cement concrete contain reactive forms of silica, the phenomenon of chemical reaction is referred to as Alkali-Silica reaction (ASR). [9]

The pozzolanic reaction occurs relatively slowly at normal temperatures enhancing strength in the longer term compare to normal Portland Cement concrete. [10]

4. EXPERIMENTAL PROGRAM

Experiment was conducted by making optimum mix of SCC containing PFA. Ingredient of concrete was made by varying of water contain, composition of filler and amount of superplastizer. Concrete cube was tested of age 1,3,7,28,90 days. The most important thing to determine whether the fresh concrete can be categorized as SCC is through rheologi test, which contain pass through and filling ability test.

Pull out test was carried out to determine bond stress of the reinforcement bar in the concrete. Concrete cylinder containing steel bar, mounted on a stiff plate and a static jack was used to pull the bar out of the cylinder. Steel bar was clamped by hydraulic jack and pull this reinforcement bar with pace rate 0.02 mm/s. Data will be analysed by computer and will produce deformation and bar force.

Concrete Mix proportions

There were two groups of mixes in this experiment. The first group was which SCC contain PFA that vary in water and the other was SCC with PFA of variation in binder amount

Table 1. Mix proportion

No	OPC	filler	CA	FA	w/b	water	S/P (%)
P1-1	450	50	925	850	0.25	125	2
P1-2	450	50	925	850	0.25	125	4
P1-3	450	50	925	850	0.25	125	6
P1-4	450	50	900	830	0.36	180	2

P1-5	450	50	900	830	0.34	170	4
P1-6	450	50	900	830	0.34	170	6
P1-7	450	50	870	820	0.42	210	2
P1-8	450	50	870	820	0.42	210	4
P1-9	450	50	870	820	0.42	210	6
P2-1	475.00	25.00	925	850	0.25	125	3
P2-2	450.00	50.00	925	850	0.25	125	3
P2-3	425.00	75.00	925	850	0.25	125	3
P2-4	449.09	23.64	941	857	0.275	130	3
P2-5	425.45	47.27	941	857	0.275	130	3
P2-6	401.82	70.91	941	857	0.275	130	3
P2-7	427.5	22.5	956	860	0.3	135	3
P2-8	405	45	956	860	0.3	135	3
P2-9	382.5	67.5	956	860	0.3	135	3
Normal	500	0	880	820	-	0.4	-

* all unit in kg/m^3

4. Result and Discussion

Compressive test

This result for compressive hardened concrete test can be shown here:

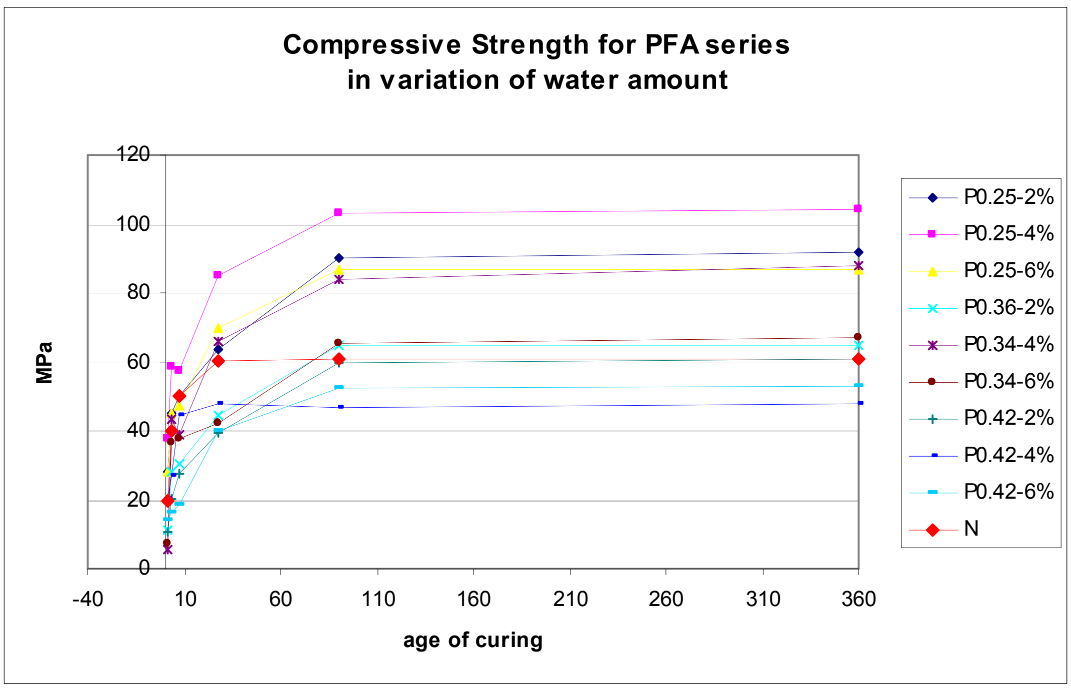

Figure 1. Strength of SCC with PFA in variation of water amount

The strength is increase for all mix proportion and achieved of high strength concrete with stress more than 50 MPa indicate that this material can be categorized as high strength concrete. Less water of this SCC produce stronger concrete. Minimum amount water for PFA series to make this concrete can be categorized as SCC that can fill the mould without vibration is 125 kg/m^3 or water binder 0.25.

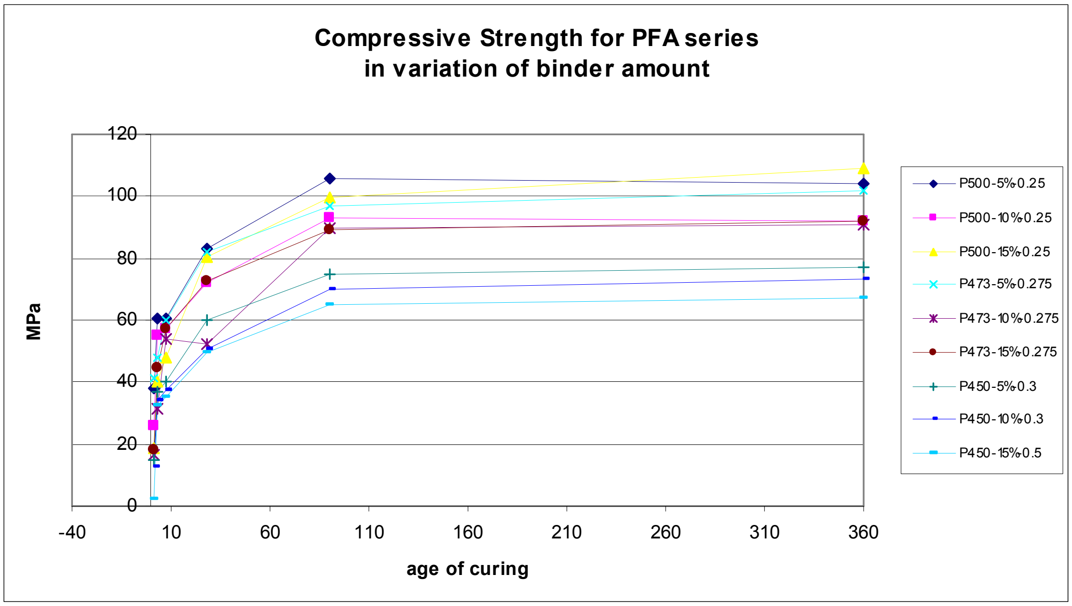

Figure 2. Strength of SCC with PFA in variation of binder amount

Less amount of PFA in SCC produced more strength but there was not significance difference by varying amount of binder in PFA series in strength growth. Overall compressive strength can be shown below.

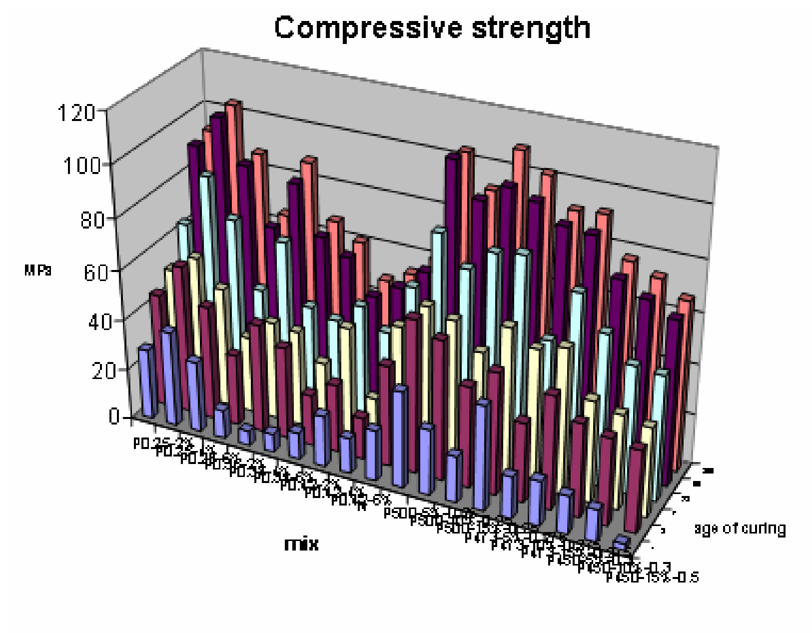

Figure 3. Overall compressive strength of SCC concrete with PFA

Pull out test

Specimen tested on curing age 7, 18 and 56 days with bar diameter was 12 mm and 16 mm. Typical bonding curves and bar force can be shown bellow.

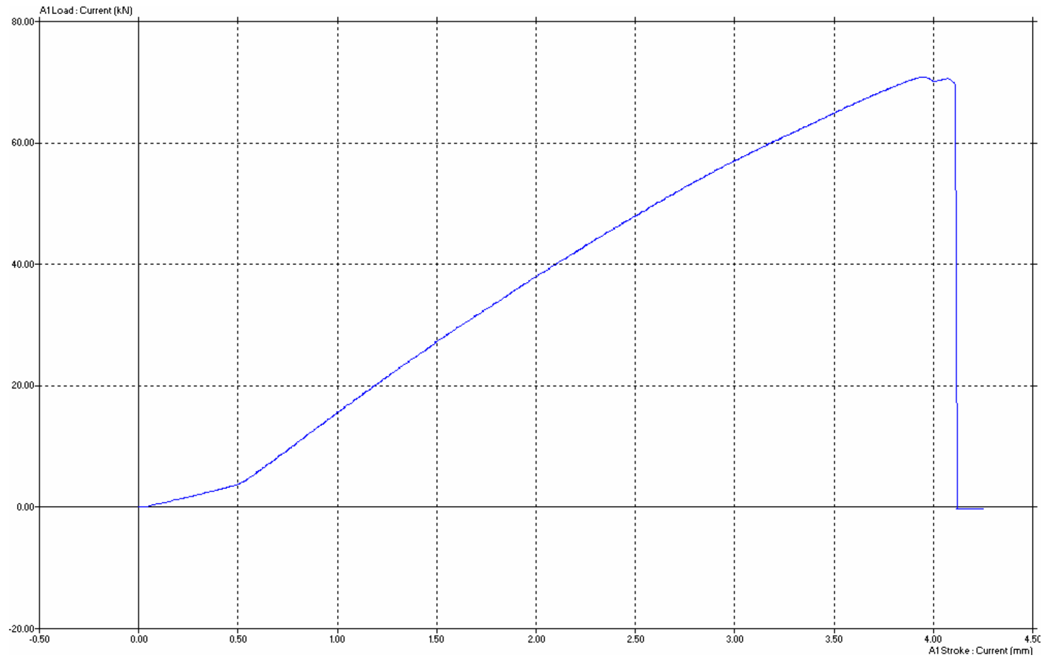

Figure 4. Typical diagram of pull out with slip curves.

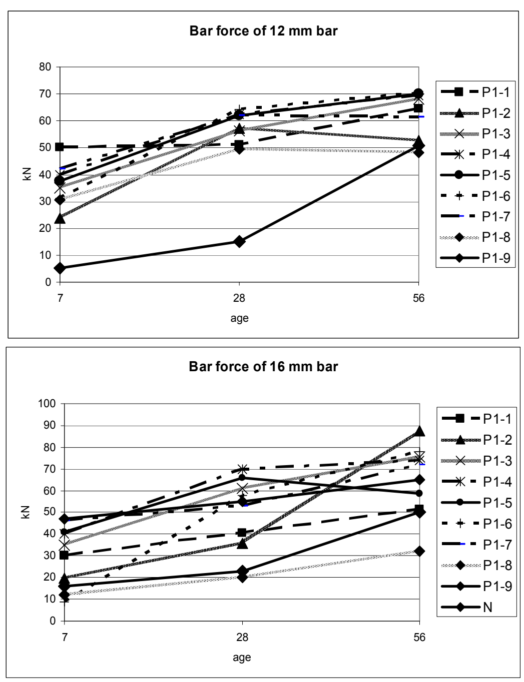

Figure 5. Bar force of 12 and 16 mm bar in concrete with PFA in variation of water amount

The bonding capacity is increase for all mix proportion. Less water of this SCC produce bonding capacity of steel bar concrete

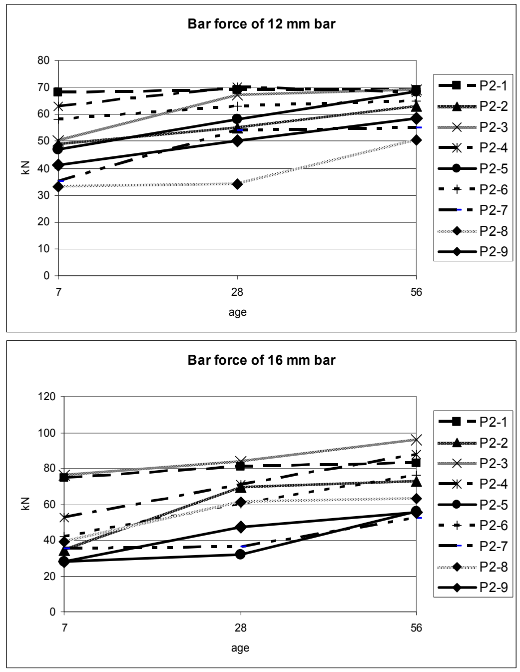

Figure 6. Bar force of 16 mm bar in concrete with PFA in variation of binder amount

Less amount of PFA in SCC produced more bonding capacity but there was not significance difference by varying amount of binder in PFA series in bonding capacity growth.

5. CONCLUSIONS

The addition of PFA is used in order to produce low cost of SCC. Base on the experiment, the following conclusion can be drawn. It was found that compressive strength of SCC with PFA had well and promises strength that could achieve high strength. Amount of water will take the critical role of strength of the concrete and also influence fluidity of SCC. PFA need minimum of water binder ratio 0.25 to achieve enough rheologi requirements and maximum of water binder ratio 0.35 to achieved high strength concrete.

This paper presents results of an experimental investigation of the performance of a bond test. Through this investigation, it was demonstrated that the most adverse conditions for bond, which occur when the concrete is under a direct tension stress field, all specimens were failed in cracked on concrete. Bigger bar reinforcement had bigger capacity of bonding. There was correlation between compressive strength and bonding capacity of reinforcement bar.

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