BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LXI (LXV), Fasc. 4, 2015
Secţia
CONSTRUCŢII. ARHITECTURĂ

WATER ABSORPTION OF SELF COMPACTING CONCRETE CONTAINING DIFFERENT LEVELS OF FLY ASH

BY

AURELIA BRADU[*] and NICOLAE FLOREA

“Gheorghe Asachi” Technical University of Iaşi
Faculty of Civil Engineering and Building Services

Received: December 10, 2015
Accepted for publication: December 280, 2015

Abstract. The water absorption of self compacting concrete (SCC) containing different levels of fly ash was investigated in this study. SCC was developed in Japan to enhance the quality of concrete. It’s a new material with a large range of powder and high workability that fill the formwork with dense reinforcement and complicated shapes without vibration. The use of fly ash as mineral admixtures reduce the material cost and increase the fresh and hardened properties of concrete. The water absorption is an essential and important step for the definition of the durability, performance and lifetime of a concrete structure. The results of 20 mixes showed that the water absorption value of SCC is affected by containing fly ash, the cement type and w/b ratio. It tend to enhance with an increase in percentage of fly ash replacement. The compressive stregth for SCC increseased with the decrease of water absorption value.

Key words: self compacting concrete; fly ash; water absorption; durability.

1. Introduction

Self compacting concrete (SCC) was developed in Japan in the late 1980s to improve the quality of concrete. This new material requires a high flowability to ensure the filling of the formwork with dense reinforcement and

[*]Corresponding author: *e-mail:* bradu_aurelia@yahoo.com

complicated shapes under the impact of gravity, without additional mechanical compactation and without segregation.

The advantages of SCC are high workability in fresh state, faster construction time, reduced labor and equipment costs, increased automation of the construction process etc.

In order to achieve self compatibility and to prevent segregation and bleeding, this type of concrete contains a large range of powder materials, superplasticisers and sometimes viscosity modifying admixtures.

While the concept of sustainable development involve the use of environment friendly materials at a reasonable cost, it is necessary to find the least expensive cement substitutes. According to Metha & Monteiro (2006), the 3 fundamental elements that decrease the negative impact of concrete buildings are:

a) conservation of primary materials;

b) holistic approach to the technology;

c) the enhancement of the durability of concrete structure.

The use of industrial by-products as mineral admixtures reduces the material cost and improves the fresh and hardened properties of concrete.

Fly ash is a by-product of burning pulverized coal in an electrical generating station. It is the unburned residue that is carried away from the burning zone in the boiler by the flue gases and then collected by either mechanical or electrostatic separators.

A high number of studies reported the benefits of using fly ash such as increasing the slump of concrete, reduced heat of hydration of the cement and eliminating the need of viscosity enhancing chemical admixture.

The objective of the present research was the examination of the effect of various content of fly ash on the absorption properties of SCC. The water absorption is an essential and important step for the definition of the durability, performance and lifetime of the concrete structure.

2. Research Significance

The pore structure of concrete is very important for the material durability. The water absorption by immersion is a relevant parameter in this respect.

Moisture migration into concrete is the main cause of concrete degradation worldwide. To understand the theory on water absorption, it is necessary to review the ways by which the fluids migrate through porous material. There are two primary water transport mechanisms in concrete: absorption and permeability.

Absorption is the ability of an unsaturated porous material to absorb fluids due to its capillary suction. This is the primary transport mechanism for water in concrete structures. It requires no pressure to function and creates far more damage potential than any other transport mechanisms.

Permeability represents the flow of water in a saturated porous material due to a pressure gradient. Performance under hydrostatic pressure is a simple function of concrete density, or cementitious content.

The water absorption by immersion gives an estimation of the total pore volume of the concrete, but does not offer any indication on the concrete permeability.

Water absorption affects the durability of concrete due to the influence of pore system and moisture migration through structure.

3. Experimental Studies

3.1. Materials

The following materials were considered, in accordance with Wongkeo & Thongsanitgarn (2014), Dinakar *et al*. (2013), Güneyisi & Gesoglu (2011), Stefanovi & Cojbasic (2007), Dinakar *et al*., (2008), Kumar, (2012).

Portland cement CEM I 42.5 N and CEM II/B-V 42.N (the percentage blending of fly ash in PPC is 28%); fly ash; washed and good quality aggregates, river sand; superplasticiser - poly carboxylate ether (PCE). In case of mixes with Portalnd pozzolana a viscosity modifier admixture was added.

The chemical and physical properties of cement and fly ash are summarized in Table 1.

Table 1
Chemical Composition and Physical Properties of Materials

Chemical composition	Cement CEM I, [%]	Cement CEM II/B-V, [%]	Fly ash, [%]
SiO_2	20.64,...,21.78	39.1	36.84,...,62.5
Al_2O_3	4.85,...,6.56	10.3	19.99,...,31.74
Fe_2O_3	3.17,...,4.13	5.82	4.2,...,15.25
CaO	60.12,...,63.62	45.7	1.7,...,1.85
MgO	1.14,...,2.08	1.79	0.14,...,0.8
SO_3	2.16,...,2.75	2.28	0.15,...,0.2
K_2O	0.42,...,0.81	0.81	0.76,...,1.76
Na_2O	0.36,...,0.51	0.14	0.12,...,0.20
Loss on ignition	2.08,...,2.39	1.72	0.31,...,1.0
Specific gravity	3.15	3.0	2.1
Blaines fineness, [m^2/kg]	307	406	350

3.2. Mix Proportion

Twenty different mixes were investigated with different fly ash dosages at different water/binder ratios (0.3; 0.35, 0.4). Total powder content varied from 450 to 600kg/m^3.

Cement content was replaced with 10, 30, 50, 60 and 70% fly ash (by mass). A Pozzolana cement (CEM II/B-V) was used for mixes SCC13-SCC16. The water/binder ratio differed from 0.35 to 0.4 for various percentages of fly ash.

The maximum size of aggregates was 20 mm an driver sand was used as fine aggregate.

The optimum dosage of superplasticiser was determined to ensure the self compatibility properties required by the Guidelines of SCC. For the mixes SCC13-SCC16 was used viscosity modifying admixtures.

The detail of the mixes for the study are presented in Table 2.

Table 2
Details of Mix Proportions, [kg/m^3]

	Cement	Fly ash	w/b	F.A	C.A.	Superplas.	VMA	f_c MPa	Abs %
SCC1	600	0	0.30	1,084	595	13.1	–	84.0	1.9
SCC2	300	300	0.30	958	595	7.5	–	66.4	2.6
SCC3	240	360	0.30	993	595	7.0	–	58.8	3
SCC4	180	420	0.30	908	595	6.7	–	45.6	3.2
SCC5	514	0	0.35	1,131	621	12.9	–	83.0	2.9
SCC6	257	257	0.35	1,023	621	6.5	–	59.2	3.9
SCC7	206	308	0.35	1,001	621	6.1	–	52.6	5
SCC8	154	360	0.35	980	621	5.8	–	39.8	4.5
SCC9	450	0	0.40	1,166	640	12.6	–	72.4	4.2
SCC10	225	225	0.40	1,072	640	5.7	–	41.9	4.5
SCC11	180	270	0.40	1,053	640	5.4	–	35.7	4.6
SCC12	135	315	0.40	1,034	640	5.1	–	31.7	5.7
SCC13	55	495	0.30	836	906	16.5	0.55	78.94	3.54
SCC14	385	165	0.30	818	888	13.8	1.1	88.06	4.53
SCC15	275	275	0.30	800	869	13.8	1.1	60.83	5.55
SCC16	165	385	0.30	783	848	11.0	2.75	44.21	12.12
SCC17	55	495	0.30	825	893	6.6	–	78.97	3.91
SCC18	165	165	0.30	798	865	4.3	–	88.06	4.61
SCC19	275	275	0.35	754	817	7.2	–	60.83	4.69
SCC20	385	385	0.35	716	775	12.3	–	44.21	6.62

3.3. Test Method

The absorption test was determined on 100 mm cubes at 28 days of water curing. The samples were dried in a hot air at 100±5ºC until a constant weight was reached. The samples were then immersed in water and the weight gain was measured at regular intervals.

The final absorption of concrete at 72h was determined.

The formula of the absorption after immersion and boiling, [%]

$$Abs\left(\%\right)=\frac{B-A}{A}\times 100 \quad (1)$$

where: A is the mass of oven dried sample in air, [g]; B – mass of surface-dry sample after immersion and boiling, [g].

4. Test Results and Discuss

$Ca(OH)_2$ is released during the hydration process of Portland cement concrete. In the presence of moisture, the fly ash reacts with the calcium hydroxide to form silicate hydrate and cementititous compounds. This reaction process consists in two parts: the pozzolanic activity of the fly ash itself and the promoting role of fly ash to the hydration of cement. The increase of fly ash content intensifies the hydration degree of cement but reduces the pozzolanic reaction. The reaction effect of fly ash is significat for 0,...,60% of fly ash content.

The pore structure of the concrete is influenced by the curing time: the capillary pores are less interconnected and the porous paste/aggregate interface zone are more dense if they are formed at early ages.

Water absorption has a direct relationship with the voids, so the absorption decrease as the voids decrease. The water absorption value of self compacting concrete containing fly ash is higher than Portland cement only at the same w/b ratio and tend to enhance with an increase in percentage of fly ash replacement. The relationship between these parameters is presented in Fig. 1.

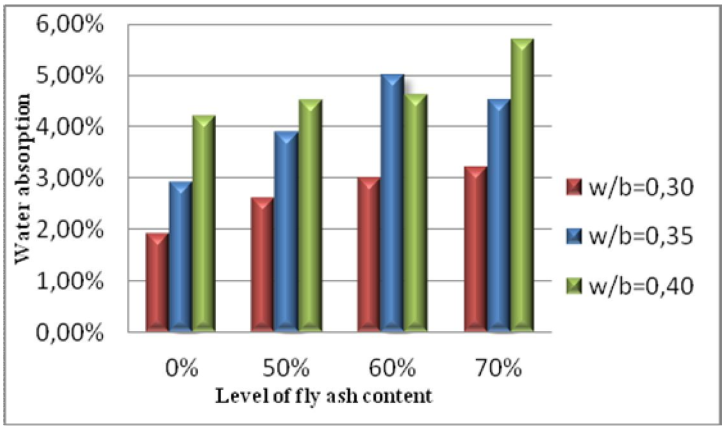

Fig. 1 – Effect on fly ash content on water absorption at various w/b ratio.

The cement type also influence the water absorption. At the same w/b ratio and the same fly ash level, the water absorption of mixes containing Portland Pozzolana cement was higher than ordinary Porland cement, it can be seen from Fig. 2.

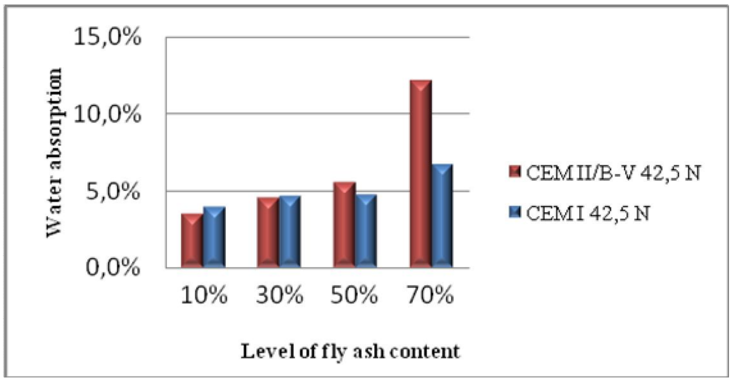

Fig. 2 – Influence of cement type on water absorption.

The compressive strength for the mixes containing fly ash was lower than the control mix. This is due to the cement dilution effect: low amount of hydration products and slow pozzolanic reaction.

The compressive stregth for SCC increseased from 10% to 30% of replacement of fly ash and start to decline from 50% of replacement.

The relationship between the compressive strength and water absorption is presented in Fig. 3.

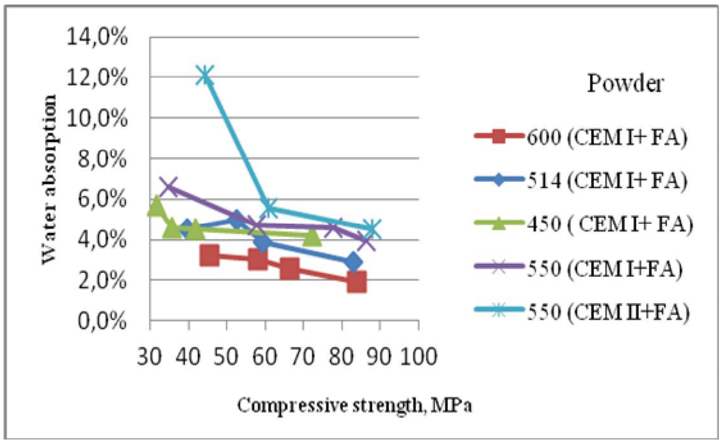

Fig. 3 – The relationship of compressive strength and water absorption.

4. Conclusions

The influence of different levels of replacement on the water absorption of 20 mixes of SCC was studied. Based on the results of this research work, the following conclusion may be drawn:

1. Water absorption has a direct relationship with the voids. The pore system of the concrete provides the transportation of the fluids and improves the absorption.

2. Water absorption value of SCC containing fly ash is higher than normal concrete only at the same w/b ratio and tends to increase with the increase in the percentage of fly ash replacement.

3. The cement type influences the water absorption process: at the same w/b ratio and the same fly ash level, it's value was higher for the mixes containing Portland pozzolana cement than ordinary Porland cement.

4. The compressive stregth for SCC increseased with the decrease of water absorption value.

REFERENCES

Dinakar P. Kartik Reddy M., Sharma M., *Behaviour of Self Compacting Concrete Using Portaln Pozzolana Cement with Different Levels of Fly Ash.* J. Materials and Design, **26**, 609-616 (2013).

Dinakar P., Babu K.G., Santhanam M., *Durability Properties of High Volume Fly Ash Self Compacting Concretes.* J. Cement and Concrete Composites, **30**, 880-886 (2008).

Güneyisi E., Gesoglu M., *Permeation Properties of Self Compacting Concretes with Mineral Admixtures.* ACI Materials J., mart/april 2011, 150-157.

Kumar D., Rajeev., *Development of Self Compacting Concrete by use of Portland Pozzolana Cement, Hydrated Lime and Silica Fume.* ISCA J. of Engng. Sci., **1**, *1*, 35-39 (2012).

Metha P.K., Monteiro P., *Microstructure Properties Materials.* 3 ed. McGraw-Hill, 2006.

Stefanovi G, Cojbasic L., *Hydration Study of Mechanically Activated Mixtures of Portland Cement and Fly Ash.* J. of the Serbian Chemical Society, **72**, 591-604 (2007).

Trezos K. G., Sfikas I. P., Pavlou D. I**.** *Water Permeability of Self Compacting Concrete.* 3rd *fib* Internat. Cong., School of Civil Eng., Grece, 2010.

Wongkeo W., Thongsanitgarn P., *Compressive Strength and Cloride Resistance of Self Compacting Concrete Containing Hight Level Fly Ash and Silica Fume.* J. Materials and Design, **64**, 261-269 (2014).

Yazıcı H., Yigiter H., Karabulut A , *Utilization of Fly Ash And Ground Granulated Blast Furnace Slag as an Alternative Silica Source in Reactive Powder Concrete.* J. Fuel, **87**, 2401-2407 (2008).

* * * The European Guidelines for Self-Compacting Concrete Specification, Production and Use, May 2005.

INFLUENȚA CONȚINUTULUI DE CENUȘĂ DE TERMOCENTRALĂ ASUPRA ABSORBȚIEI DE APĂ A BETONULUI AUTOCOMPACTANT

(Rezumat)

Este prezintat un studiu al variației absorbției de apă a betonului autocompactant realizat cu cenuşă de termocentrală. Betonul autocompactant a fost inventat de către cercetătorii japonezi cu scopul de a îmbunătăți proprietățile betonului tradițional. BAC conține o cantitate mai mare de materie fină care îi conferă o fluiditate sporită, abilitate de trecere prin zonele intens armate cu secțiune redusă fără a segrega şi nu necesită vibrare. Utilizarea cenuşei de termocentrală în calitate de adaos mineral reduce costul de producere a BAC şi îmbunătățeşte caracteristicile acestuia în stare plastică şi întărită. Absorbția apei reprezintă un factor important în determinarea durabilității betonului. Conform rezultatelor obținute în urma analizei a 20 de amestecuri de BAC, s-a stabilit că absorbția este influențată conținutului de cenuşă de termocentrală, a tipul de ciment şi a raportului apă/pulberi. Valorea ei creşte odată cu sporirea cantității de cenuşă de termocentrală. Rezistența la compresiune descreşte odată cu creşterea absorției.