



Comparison on efficiency factors of F and C types of fly ashes

Hasan Yildirim^{a,*}, Mansur Sümer^b, Veysel Akyüncü^b, Emrah Gürbüz^b

^a Istanbul Technical University, Faculty of Civil Engineering, Istanbul, Turkey

^b Sakarya University, Faculty of Civil Engineering, Sakarya, Turkey

ARTICLE INFO

Article history:

Received 7 September 2010

Received in revised form 5 December 2010

Accepted 7 December 2010

Available online 12 January 2011

Keywords:

Class F fly ash

Class C fly ash

Compressive strength

Efficiency factor

ABSTRACT

Fly ashes are obtained from thermal power plants and they are pozzolanic materials, which can act as partial replacement material for both portland cement and fine aggregate. With their economical advantages and potential for improving fresh and hardened concrete performance, they have some benefits for using in concrete industry. In this study, the objective was to find the efficiency factors of Turkish C and F-type fly ashes and to compare their properties. Three different cement dosages were used (260, 320, 400 kg/m³), two different ratios (10% and 17%) of cement reduced from the control concretes and three different ratios (depending on cement reduction ratio) of fly ash were added into the mixtures. At the ages of 28 and 90 days, compressive strength, modulus of elasticity and ultrasound velocity tests were carried out. From the compressive strength results, the *k* efficiency factors of C and F-type fly ashes were obtained. As a result, it is seen that efficiency factors of the concrete produced by the replacement of F and C type fly ashes with cement increase with the increase in cement dosage and concrete age.

Crown Copyright © 2010 Published by Elsevier Ltd. All rights reserved.

1. Introduction

The cement which is one of the main component of the concrete has an important place in the cost of concrete. The environmental damage of cement production is substantially higher; approximately 1 ton of CO₂ gas is emitted for every ton of cement produced [1]. In addition, production of cement requires more amount of energy. Today, using various pozzolanic materials instead of cement in concrete production, tends to be more economical.

Pozzolan has non-binding properties when it is stand alone, but it has binding properties just after being granulated finely and chemical reaction with the calcium hydroxide at the normal temperature and humidity [3]. The most common pozzolan is fly ash. This material is a by-product of burning granulated coals in the thermal power plants. It is obtained by cumulating fine particles in the dust collection system before leaving the flue gases into the atmosphere [2].

Fly ash particles are generally spherical with a diameter of 1–150 µm [4]. Chemical composition and properties of fly ash depends on the structure and composition of coal and the process of burning [5]. Fineness of fly ash significantly affects pozzolanic activity. Fly ashes are classified as F-type and C-type [4]. There are 11 thermal power plants actively working in Turkey but F-type fly ash is obtained only from Çatalağzı Thermal Power Plant, fly ash

of all other plants is C-type. The annual fly ash production in the world is approximately 450 million tons, but that only 6% are used in cement and concrete industry [6]. In Turkey, the annual production is approximately 15 million tons, but usage is low in the industry. There are two reasons:

- Inadequate information about the fly ash properties.
- Fly ash properties are not always uniform [7,8].

Fly ashes consist mainly of SiO₂, Al₂O₃, Fe₂O₃, and CaO and some impurities. According to ASTM C618 [9], fly ash belongs to Class F if (SiO₂ + Al₂O₃ + Fe₂O₃) > 70%, and belongs to Class C if (SiO₂ + Al₂O₃ + Fe₂O₃) > 50%. Usually, Class F fly ashes have a low content of CaO and exhibit pozzolanic properties, but Class C fly ashes contain up to 20% CaO and exhibit cementitious properties [10].

In the available literature, many studies regarding the effect of optimum use of fly ash may be found. Öner et al. [10] found that strength increase with this study showed that strength increases with increasing amount of fly ash up to an optimum value, beyond which strength starts to decrease with further addition of fly ash. The optimum value of fly ash for the four test groups is about 40% of cement. Fly ash/cement ratio is an important factor determining the efficiency of fly ash.

Papadakis and Tsimas [11] and Papadakis et al. [12] investigated the efficiency factor and supplementary cementitious material [SCM] design in concrete and reported that when SCM replaced aggregates, higher strength values compared to the control mixtures were obtained. Papadakis also studied low-calcium fly ash in portland cement systems in other works and reported these two results:

* Corresponding author. Address: Materials Science Department, Civil Engineering Faculty, Istanbul, Turkey. Tel.: +90 212 285 3761; fax: +90 212 285 6587.

E-mail address: yildirimhasan63@hotmail.com (H. Yildirim).

- If low lime fly ash-aggregate changing is done, higher strength is obtained after 14th day but it is obtained after 91th day if low lime fly ash–cement changing is done.
- If aggregate content is reduced and high lime fly ash is added, beginning from starting of hydration, higher strength and lower porosity are observed. But if cement is reduced instead of aggregate strength remains stable [13].

Ganesh Babu and Rao [14] researched the efficiency factor of fly ash in concrete, considering the strength to water/cement ratio relations, age and percentage of replacement. It is reported that the overall cementing efficiency (k) of fly ash was established through a general efficiency factor (k_p), which depends on the age of concrete specimen and replacement percentage, respectively.

In this study, an experimental investigation of optimum use of fly ash in concrete was carried out. Optimum efficiency of fly ash amount was determined for concrete with various cement dosages. From the compressive strength results and water/cement ratios, the k efficiency factors of F and C type fly ashes were obtained using Bloomy formula.

2. Experimental work

2.1. Materials

In this study, CEM I 42.5 Portland cement, Class C and F fly ashes were used as binding materials. Their chemical compositions and properties are shown in Table 1. Both C and F class fly ashes were obtained from power plants in Turkey. 25% natural sand with density of 2.66 g/cm³, 19% of fine aggregate, 29% of crushed stone no 1 and 27% of crushed stone of no 2 are used in concrete mixtures. The fineness modulus of the mixture is 4.09. Volume percentages of aggregates were kept constant in all mixtures. 36 series of concretes containing fly ash and 3 series of control mixtures were produced in order to calculate the Bolomey coefficient (K_B).

Table 1
Chemical compositions (%) and properties of binding materials.

Binder	H ₂ O	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	K ₂ O	Cl	LOI	Free CaO	SG gr/cm ³
Chemical compositions (%) fly ash (F)	0.2	58.58	23.4	6.97	1.55	2.76	0.45	0.46	4.11	0.0319	0.2	0.1	3.12
Chemical compositions (%) fly ash (C)	0.2	46.38	13.9	8.26	15.1	6.68	4.26	2.13	2.78	0.0638	0.22	0.15	1.84
Chemical compositions (%) cement	–	20.63	4.71	3.41	63.64	1.24	2.98	0.23	0.91	0.0357	1.25	1.1	2.34

Loss on ignition (LOI), specific gravity (gr/cm³) (SG), specific surface (cm²/gr) (SS).

Table 2
Mix proportioning (kg/m³) of concrete.

Concrete type	Cement (kg/m ³)	Remove (%)	Fly ash (kg/m ³)	Added (%)	Water (kg)	Air content (%)	Slump (cm)
F TYPE							
C260F0 (%0K0)	260	0	0	0	199	2	15.5
C234F39 (%10K1,5)	234	10	39	15	195	2.1	16
C234F52 (%10K2)	234	10	52	20	196	1.9	15.5
C234F65 (%10K2,5)	234	10	65	25	197	2.2	14
C216F44 (%17K1)	216	17	44	17	196	2.4	15.5
C216F66 (%17K1,5)	216	17	66	25.5	196	1.7	14
C216F88 (%17K2)	216	17	88	34	197	2	14
C320F0 (%0K0)	320	0	0	0	205	2.3	15.5
C288F32 (%10K1)	288	10	32	10	186	1.6	15.5
C288F48 (%10K1,5)	288	10	48	15	192	1.6	15
C288F64 (%10K2)	288	10	64	20	201	1.8	14.5
C266F54 (%17K1)	266	17	54	17	196	1.9	14.5
C266F81 (%17K1,5)	266	17	81	25.5	201	2.1	16
C266F108 (%17K2)	266	17	108	34	203	2	16
C400F0 (%0K0)	400	0	0	0	172	3	15
C360F40 (%10K1)	360	10	40	10	160	2.5	17
C360F60 (%10K1,5)	360	10	60	15	162	2.7	17
C360F80 (%10K2)	360	10	80	20	170	2.2	17
C332F68 (%17K1)	332	17	68	17	165	2.4	16
C332F102 (%17K1,5)	332	17	102	25.5	164	2.4	17
C332F136 (%17K2)	332	17	136	34	180	3	15.5

2.2. Specimen preparation and curing

In each series, 6 cube specimens (15 × 15 × 15 cm) and 3 cylinder specimens (20 cm length and 10 cm radius) were produced. Three different cement dosages were used (260, 320, 400 kg/m³) two different ratios (10% and 17%) of reduced cement from the control concretes and three different ratios (depending on cement reduction ratio) of fly ash were added into the mixtures.

The workability values of mixtures were similar to each other with a slump of 140–170 mm. The main variable in the mixtures was the cement, fly ash and the water content. The mixture proportions of concrete are shown in Tables 2 and 3. The raw materials of concrete were put in a forced mixer at the same time and were mixed for 3 min. The workability of fresh concrete including slump was measured immediately after the mixing was completed. The results are listed in Tables 2 and 3. Slump, density and the air content of fresh concrete were obtained. The mixtures were cast into test specimens in mould by vibration. After casting, the specimens were demolded after 1 day and were cured in water at 23 °C until testing.

2.3. Testing

At the ages of 28 and 90 days, ultrasound velocity (according to ASTM C469 – 10) and compressive strength tests were carried out on cube specimens. As for cylinder specimens elasticity modulus tests (according to ASTM C597 – 09) and ultrasound velocity were carried out at 28th day. For all results, the average of experimental results from three identical specimens was adopted.

3. Results

3.1. Compressive strength

In compressive strength test, the loading rate for cube specimens was 13 kN/s. The specimens were tested until complete crushing. The results of the compressive strength tests are given in Tables 4 and 5 and Figs. 1–4.

Download English Version:

<https://daneshyari.com/en/article/10285275>

Download Persian Version:

<https://daneshyari.com/article/10285275>

[Daneshyari.com](https://daneshyari.com)