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EFFECT OF SILICA FUME WITH HYDRATED LIME ON COMPRESSIVESTRENGTH AND CARBONATION RATE OF C25 CONCRETE

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ABSTRACT

In this study 11 different combinations of micro fly ash and calcium oxide were replaced instead of cement. Fly ash with 5%, 10%, 15% and 20% of cement and calcium oxide with 5%, 10%, 15% and 20% of cement and then a combination with fixed 15% fly ash and 5%, 10% and 15% of calcium oxideare replaced instead of cement. Then 108 sample of cubic concrete have been prepared and samples at the ages of 7, 28 and 56 days were applied compression strength and ultra sound tests and results were recorded and compared. According to the results, the samples had the best results at 56 days. The reasonfor the good results at 56 days was the entry of pozzolan into the system and its reaction with calcium hydroxide resulting from the hydration reaction.

KEYWORDS: Fly ash, Calcium oxide, Compression strength test, Ultra sound test, Pozzolan.

1. INTRODUCTION

In the present are, concrete is the material which is ranked second in the world in terms of per capita consumption that's why addressing these materials as a main ingredient in most constructions should be followed up and investigated more than now in our country. One of the main part of concrete which greatly affect the price of it is cement.[1] Nowadays in the world there is a big competition in the supply of natural resources and the creation of green product. This competition is more engineering than structures due to its economic. The use of

Nano technology and micro materials are getting more in building due to their economic justification. The materials are replaced the cement in concrete which has the biggest affect in the price of concrete because they are economical.[2] The use of pozzolans hasbeen common in Japan and America since 1940. Fly ash is one the major functional pozzolans which is collected and land filled from the chimneys of power plants by filtration or tornado method in order to prevent air pollution. This material because of containing Silicon oxide, Aluminum oxide and Iron oxide has the pozzolanic property. İn the USA, out of 45 million tons of produced fly ash 1o million tons are applied in constructions.[3]

Additives are substances that are used to reinforce some of the properties of concrete which areavailable in three types in researches and resources.

1. Natural additives (volcanoes, volcanic ash, Stone powder, terraces and diatomaceous)
2. Materials from factories and residuals (fly ash, silica and materials from the molten metal)
3. Materials which are produced from some reactions and energy (baked clays, powder clays, the pollenof cermet, and the pollen of Kermit).[4]

2. MATERIAL AND METHOD

Fly ash is one of the common pozzolans which is collected from the sooty ashes returned out of the chimneys which are built in the coal - fired power plants .This is done by filters built into the chimneys to prevent the ashes to be scattered in the air (Figure 1). It is used in industrial work. The grain size of the fly ash changes from 5 to 150 Micron and its annual production is 45 million tons which only 6% is applied in civil structures .united states of America and India produce in order 45 and 50 million tons ofit.[5]

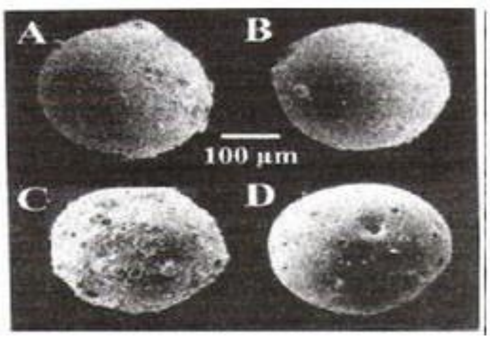

Figure 1: ***Types of fly ash.***[6]

Figure 1 shows the types of fly ash of the fuel used in ovens. From the profile view of fly ash can be noted the surface area of 1500 to 5000 cm^2 / gr and mass weight of 2.2 to 2.7 gr/cm^3.

Fly ash can be divided into groups F and C in the standards of ASTM C618 and TSEN 197-1 which isvisible in Table 1.[7]

Table 1: ***Different types of fly ash.***

Element	**SiO2**	**Al2O3**	**Fe2O3**	**CaO**	**MgO**	**K2O**	**Na2O**	**SO3**	**Li2O**
Down F	46-57	18-29	6-16	1.8-5.5	1.8-5,5	1.9-2,8	0.2-1,1	0.4-2,9	0.6-4,8
F Up	42-54	16.5-29	16-24	1.3-3,8	0.3-1,2	2.1-2,7	0.2-0,9	0.5-1,8	1.2-5
Down C	25-42	15-21	5-10	17-32	4-12,5	0.3-1,6	0.8-6	0.4-5	0.1-1
Up C	*46-59*	*14-22*	*5-13*	*8-16*	*3.2-4,9*	*0.6-1,1*	*1.3-4,2*	*0.4-2,3*	*0.1-2,3*

Elements of fly ash used in this research has been shown in Table 2.

Table 2: ***Chemical analysis of fly ash.***

Name of element	**CaO**	**SiO2**	**Al2O3**	**Fe2O3**	**MgO**	**SO3**	**K2O**	**Na2O**	**Loss On Igition**
Percent of elements	31.8	36.48	15.32	3.94	2.3	4.37	1.16	0.66	3.64

Table 2 shows the fly ash analysis used in this study. Depending on the amount of calcium oxideavailable, we can put this fly ash in class C DOWN.

Table 3: ***Sieving analysis of used fly ash.***

Number of sieve (mm)	1	0.5	0.15	0.09	0.075	Through of 0.075
Residue on sieve before grinding (gr)	0	2	32	26	21.5	168.5
Before grinding%	0	0.008	0.128	0.104	0.086	0.674
Residue on sieve after grinding(gr)	0	0	17.5	18	14	200.5
After grinding %	0	0	0.07	0.072	0.056	0.802

Pozzolanic activity of fly ash after test which is according to the standard of ASTM has been done with1375 g of standard sand, 500 g of cement and 242 g of water in the first sample and with 400 g of cement, 100 g of fly ash in the second sample by the name of FA. According to the standard of 28 -daytrial. The second combination, must have had at least 75% of the first sample which has been prepared with pure cement.

Table 4: ***Compressive strength test of pozzolanic activity.***

	7 days	**28 days**	**56 days**
100%CİMENTE (MPa)	38.6	44.5	49.4
25%FA (MPa)	38.2	42	48.8

Table 4 and Figure 2 show the result of the compressive strength test of the specimens. When the results are compared with each other, it can see easily that all specimens which include fly ash providepozzolanic activity conditions.

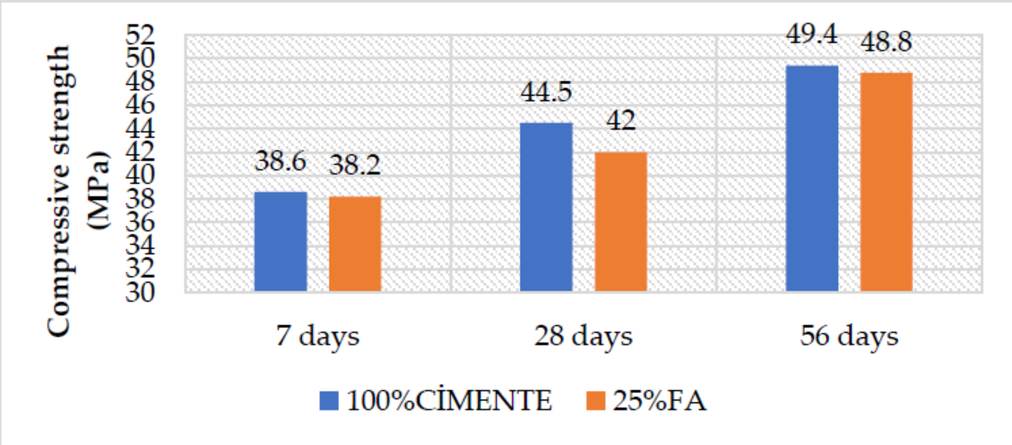

Figure 2: Diagram for compressive strength test of pozzolanic activity.

Figure 3 show that bending strength results of the specimens including fly ash at all ages of 7, 28 and 56 days are 75 % bigger than the specimens including 100 % cement. Also, the specimens including flyash provide pozzolanic activity conditions.

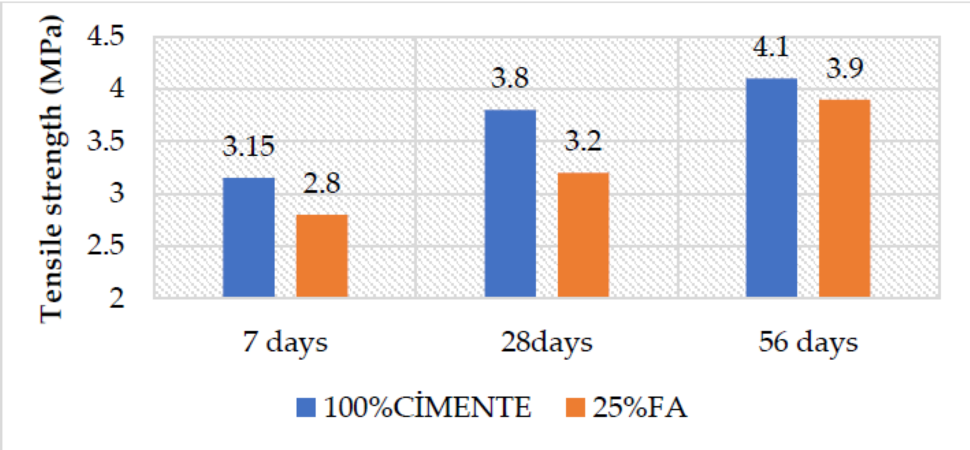

Figure 3: ***Analysis of tensile strength of fly ash.***

3. Hydraulic Lime

Hydraulic lime which is made of lime stone baked with low percent of clay is grinded in saturated aqueous environment by the wet method .the lime which changes to calcium hydroxide exposed to water has the hardening ability by getting carbon dioxide .this feature makes it a hydraulic binder.[8]

$CaO + H_2O \Longrightarrow Ca(OH)_2 + ISI$

$Ca(OH)_2 + CO_2 \Longrightarrow CaCO_3 + H_2O.$

2.2. Portland Cement Type 425-1 normal

Portland cement type 425-1in national standard of ASTM C 150 is called as a Portland cement type 1 which has been classified with defiance of 4 kilograms per square centimeter. Its characteristics are in Table 5.[9]

Table 5: Chemical and physical properties of Portland cement type 425-1 normal.

CaO	SiO2	Al2O3	Fe2O3	MgO	Na2O	K2O	SO3	Loss on ignition	Specific gravity
60-67	17-25	3-8	0.5-6	0.1-4	0.2-1.3	0.6-1	1-3	2.20	3.06

Concrete is designed on the basis of 25 MPa. Hydraulic lime and fly ash with different percentages which have been shown in Table 7 and 8 replaced instead of cement in compound.

Table 6: Explanation of abbreviation and their type of combination.

The control sample	The aim concrete with 10% of cement and fixed sieving
5%FAC	Concrete with 5% micro of fly ash instead of cement
10% FAC	Concrete with 10% of micro fly ash instead of cement
15%FAC	Concrete with 15%of micro fly ash instead of cement
20%FAC	Concrete with 20% of micro fly ash instead of cement
5%LC	Concrete with 5% of hydraulic lime instead of cement
10%LC	Concrete with 10 % of hydraulic lime instead of cement
15%LC	Concrete with 15% of hydraulic lime instead of cement
20%LC	Concrete with 20% of hydraulic lime instead of cement
15%FA5%LC	Concrete with 15% micro fly ash and 5% hydraulic lime instead of cement
10%FA10%LC	Concrete with 10% of micro fly ash and 10% hydraulic lime instead of cement
5%FA15%LC	Concrete with 5% of micro fly ash and 15% hydraulic lime instead of cement

Table 6 shows the single mixing scheme to be tested. As can be seen, the percentages start from 5 andup to 20% have been replaced by the weight of the cement.

Table 7: Percent's of the applied mix.

	Sieving Millimeter 11.2-22 (kg)	sieving Millimeter8-11.2 (kg)	Cement 42.5 (kg)	Calcium oxide L (kg)	Fly ash FA (kg)	Water (kg)
The controlsample	618	618	340	0	0	**170**
5%FAC	618	618	323	0	17	**170**
10% FAC	618	618	306	0	34	**170**
15%FAC	618	618	289	0	51	**170**
20%FAC	618	618	272	0	68	**170**
5%LC	618	618	323	17	0	**170**
10%LC	618	618	306	34	0	**170**
15%LC	618	618	289	51	0	**170**
20%LC	618	618	272	68	0	**170**
15%FA5%LC	618	618	272	51	17	**170**
10%FA10%LC	618	618	272	34	34	**170**
5%FA15%LC	618	618	272	17	51	**170**

As we can see in Table 7, the amount of water is constant, but the amount of cement varies accordingto the replacement of fly ash and cement. The amount of granulation is the same for all compounds.

4. RESULTS AND DISCUSSION

According to mix (Table 6) cubic samples prepared and compressive strength and speed of sound of thesamples were tested after 7,28and 56 days. Results are shown in Tables 8.

Table 8: Compressive strength of samples.

Name of sample	The control sample	5%FAC	10% FAC	15%FAC	20%FAC	5%LC	10%LC	15%LC	20%LC	15%FA5%LC	10%FA10%LC	5%FA15%LC
7 days(MPa)	22	21.3	21.1	19	16.5	21.5	20.8	20.2	19.9	20.1	21.2	21.4
28 days(MPa)	31.3	30.4	29.5	29.1	27	31.9	30.3	31.1	28.3	30.8	31.5	31
56 days(MPa)	39.3	40	43	37.1	36.6	40.5	35.8	35.8	33.3	43.4	37.5	35.2

Table 8 and Figure 4 show that control specimen provides the best strength between samples at ages of7 days. In 28-day samples, the lowest strength in concrete with 20% is fly ash and the highest resistance in concrete with 5% of lime. The reason for its high resistance was the increase in hydrationheat due to the increase in lime.

In the 56-day samples, because the pozzolanic activity has reached its peak, the concrete sample with 15% fly ash and 5% lime with 43.4 MPa had the best results. This was due to the participation of some fly ash in the conversion of calcium hydroxide to calcium silicate hydrate.

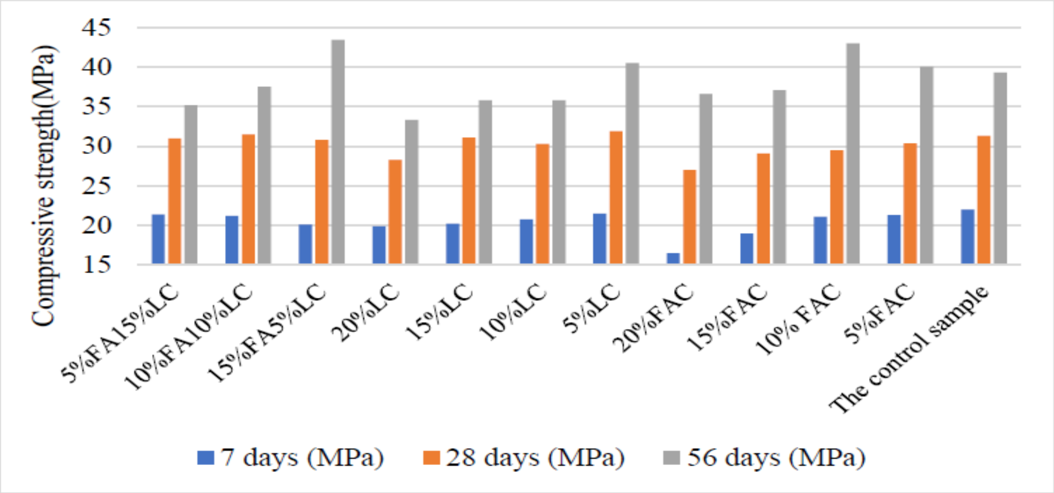

Figure 4: Diagram for compressive strength of sample.

As we can see in Table 4, the samples with 10% fly ash and 15% ash and 5% lime samples with an approximate jump of 100% created a good distance with the dipper samples. This indicates the compatibility of fly ash with lime.

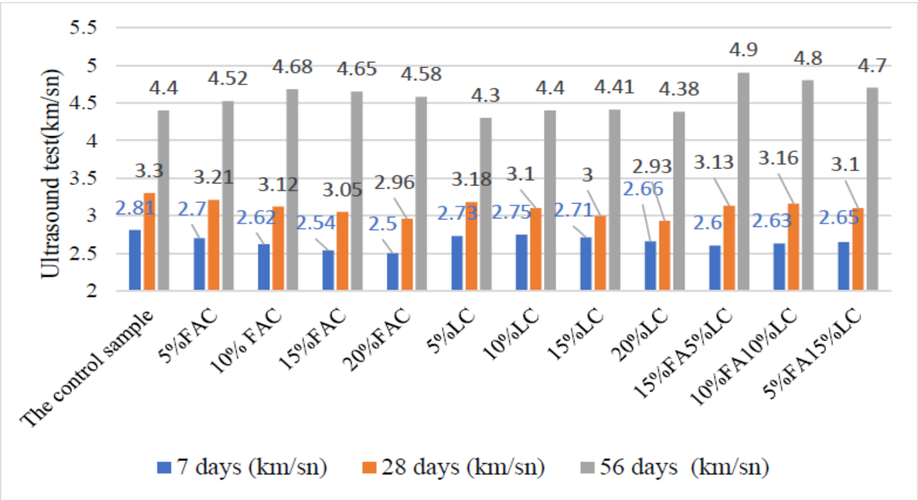

Figure 5: Diagram for the speed of sound test.

In Figure 5 ultrasonic results are also improving with the age of the samples. At 7 days, as in the previous experiment, the control sample had the best results. With age, only specimens with pozzolans increase the difference. According to the chart, after 56 days and activation of pozzolanic reactions, the sample with 10% ash ash had the best result among the samples with pozzolan. A better result was obtained by combining lime and pozzolan. The sample with 15% fly ash and 5% hydrated lime had the best result with 4.9 km / s. The reason for this increase in transfer rate may be due to the structure composed of thecombination of pozzolan with excess calcium oxide, which could lead to a decrease in resistance.

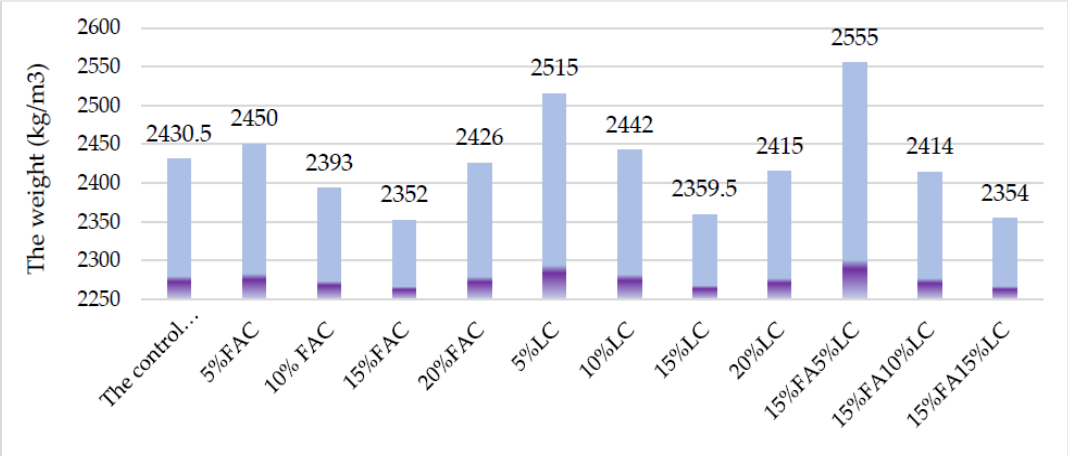

Figure 6: Specific gravities.

Carefully in Figure 6 we see that there is a significant relationship between compressive strength and ultrasonic testing with the weight of the samples. And the samples that had more specific gravity also showed better results in experiments that samples 15%FA5%LC and 5%FAC with 2555 and 2515 hadthe highest and sample 15%FAC with 2352 kg / m3 had the lowest specific weight.

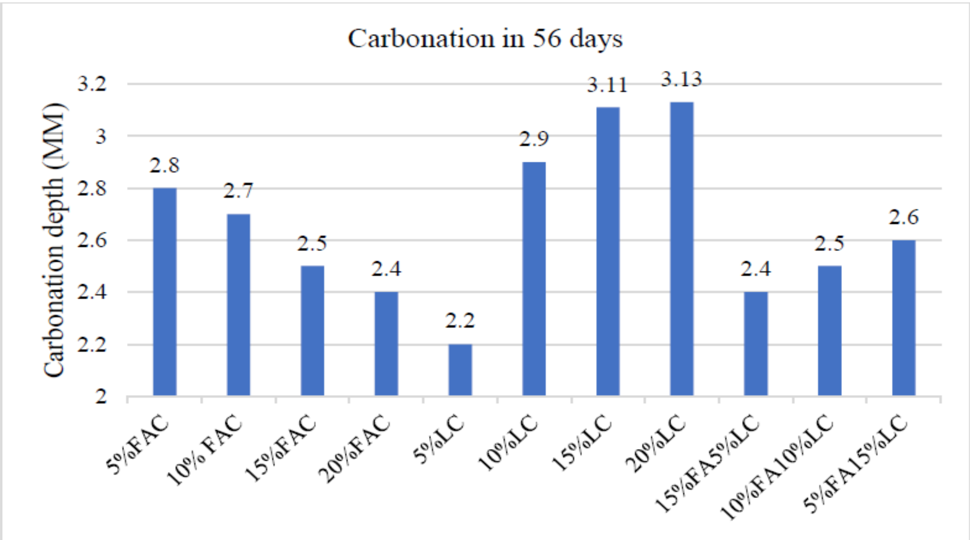

Figure 7: Carbonation depth in elements.

As we can see in Figure 7, carbonation has been different in all mixing steps. The carbonated process is different compared to different additives. With the increase of fly ash, the amount of carbonation decreased and with the increase of hydrated lime, the amount of carbonation increased. In the combination of ash with lime, with the increase of hydrated lime, the rate of carbonation was ascending.

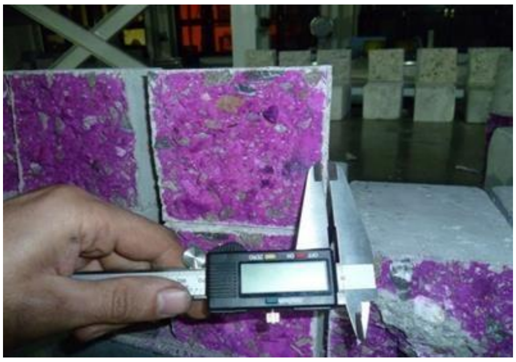

Figure 8: Depth of carbonation.

Figure 8 shows an example of the amount of carbonation that is accurately measured by a caliper.

5. CONCLUSION

İn control samples, resistance of 7 days to 56 days has increased 34% and reached to 39.3 MPa while the increase has reached to 44MPa in samples of 10% FAC with 66% and to 40.5 MPa in samples of 5% CL with the increase of%٩٨ compared to ٧- day sample. İn the mixture of the two materials in the sample of 15%FA5%LC, two parameters of quality and economy is completely ideal due to the more formation of silica calcium hydrate gel, besides, excessive calcium hydroxide is the combination of calcium oxide which reproduces silica calcium hydrate after some time and pozzolanic activity and it is also added to concrete strength. 28 day resistance of combinations FAC 10% and FAC 5% in order 2 and 9 is more than the control sample more important is that combination 15%FA5%CL with 35.9 MPa has the maximum compressive strength. It's also has the maximum compressive strength with replacing of 20% instead of cement in 56 days. The sample of 15%FA5%CL with 43.4 MPa has an increase of 10% compared to control concrete. Regarding to above the combination of pozzolan silica with calcium oxide is an ideal combination with high strength and more economical to replace the optimum percentage of cement. In addition to adding strength and being economic that would be the factor to prevent air pollution for cement production and loss of natural resources.

REFERENCES

1. Berry, E.E. and Malhotra, V.M., “Fly Ash for Use in Concrete –A Critical Review”, J. of AmericanConcrete Institute, March-April 1980; 59-73.
2. Erdogan, T.Y., “High-Lime Fly Ash Concretes,” Proceedings, Cairo First International Conferenceon Concrete Structures, Jan 1996; 1: 4-1 to 4-9.
3. Lam, L., Wong, Y.L. and Poon, C.S. Effects of Fly Ash and Silica Fume on Compressive and Fracture Behavior of Concrete. Journal of Cement and Concrete Research, 1998; 28: 271-283.
4. Tarun, R., Bruce, W., "High Early Strength Fly Ash Concrete for Precast", PCI Journal, 1990; 35(6): From 72 to 78.
5. Han, S.-H., Kim, J.-K., and Park, Y.-D. “Prediction of compressive strength of fly ash concrete by new apparent activation energy function.” Cement and Concrete Research, 2003; 33: 965-971.
6. Yoon, Y.S., Won, J.P., Woo, S.K. and Song, Y.C., “Enhanced Durability Performance of Fly Ash Concrete for Concrete-Faced Rockfill Dam Application”, Cement and Concrete Research, 2002; 32: 23-30.
7. Alasali, M.M., Malhotra, V.M., Concrete Solution for Sustainable Development. International Materials Journal, 2000; 97(1): 41-48.
8. Malhotra, V.M., High performance, high-volume fly ash concrete. Concrete International, 2002; 24(7): 30-34.
9. Baharavar, S., Simsek, O., 2013, “Reinforcement of C25 concrete with metal fibers and fly ash andstudy of some concrete properties and its effect on the amount of carbonation of concrete”, International Conference on Civil Engineering, Architecture and Sustainable Urban Development, Iran.