THE EFFECT OF THE USE OF MINERAL ADDITIVES ON EARLY AND ADVANCED AGE COMPRESSIVE STRENGTH OF HIGH STRENGTH CONCRETES

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ABSTRACT

In this study, the effect of using certain proportions of fly ash, Silica fume and milled blast furnace slag instead of cement on the early and final pressure resistances of the high strength concretes has been examined. Within the framework of the experiments, Silica fume has been changed in a ratio of 0-10 %, milled blast furnace slag between 0-50 %, and fly ash between 0-25 % by means of making the usage rates of the aforementioned three different mineral additives. "Water/Binder" rate, which is known to be an important parameter in terms of the compressive strength of concrete, has been changed as 0.20, 0.25 and 0.30 in the context of the experiments, and 100x100x100mm cube samples have been taken from the mixtures generated separately for each mineral additive type. This samples 2, 7, 28, 56 and 90-day pressure resistance have been tested.

KEYWORDS

High strength concrete, Fly ash, Milled blast furnace slag, Silica fume, Water/Binder ratio.

1. INTRODUCTION

Mineral additives are materials which contain 5-35 % calcium oxide (CaO), and 70-90 % reactive oxides (SiO_2, Al_2O_3, Fe_2O_3) in them, with pozzolanic features, fine grain (grain size 0-150µm), whose natural and artificial forms are found. Artificial mineral additives class comprises of fly ash [1-9], and Silica fume [10-17], and ground granulated blast furnace slag [18- 24]. The reason why they are called artificial arises from the fact that they are not readily found in nature, and that they are obtained during industrial production. The use of artificial mineral additives, each of which is an industrial waste, in concrete and cement has been found based on the works of disposal of these materials. With the increase of the industrial production, the amounts of artificial mineral additives obtained as a by-product also have increased with each passing day, and their storage and disposal began to create big ecological and economic problems. The experts looking for solutions to this problem have examined the artificial mineral additives, and noticed that their contents are very similar to Portland cement. Thanks to this, the use of artificial mineral additives in concrete directly and/or cement additive have been found. As a result of the studies made, it has been observed that the artificial mineral additives used in concrete by replacing with cement in appropriate amounts can give higher pressure resistances compared to concretes produced by using only cement.

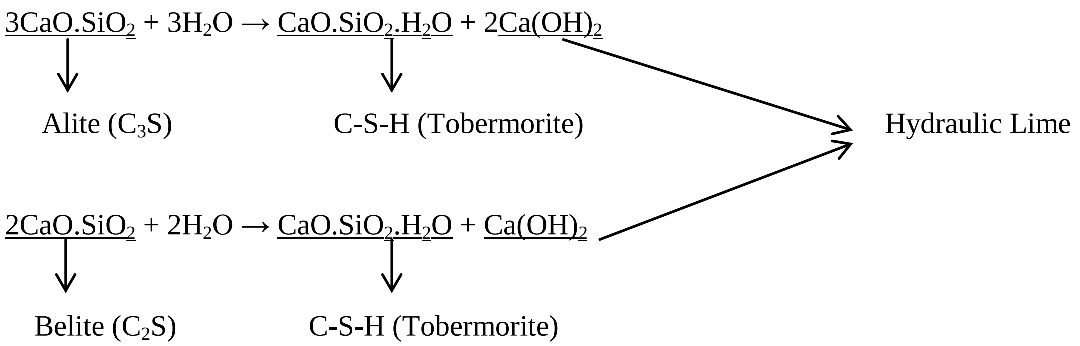
The reason why higher pressure resistances are reached in concretes produced with artificial mineral additives used by switching with cement in an appropriate amount is the addition of siliceous, alumina and ferrous (SiO_2, Al_2O_3, Fe_2O_3) compounds which are largely reactive to bindingness unlike cement. These compounds form solid crystals over time by reacting with hydraulic lime $Ca(OH)_2$ released as a result of hydration of cement. [25] At the end of the hydration of cement, C-S-H (Calcium silica hydrate) is generated at a rate of 50-60 %, and $Ca(OH)_2$ in a rate of 20-25%. In the concrete mixture content, the decrease of $Ca(OH)_2$ rate and increase of C-S-H rate undoubtedly improves the concrete pressure resistance. The speed and the amount of resistance that can be obtained by the Portland cement paste in concrete depends on how fast and in what amount the calcium-silicate-hydrate (C-S-H) gels released as a result of the reactions of the calcium silicate main components in cement with water are constituted. The faster the C-S-H gels are generated, the greater the speed of the cement to gain resistance; the more it is generated, the higher is the resistance. [26] Due to the fact that C-S-H rates in the concretes produced by using mineral admixtures are higher compared to the concretes produced with only cement, higher pressure resistances can be achieved.

In the present study we have done, it has been aimed to determine the early and final pressure resistance differences created by fly ash, milled granulated blast furnace slag and Silica smoke used separately by switching with cement in different rates on high strength concretes (HSC). In our TS 13515 - 14 standard, high strength concrete has been defined as “normal or heavy concretes whose pressure resistance class is higher than C50/60 high resistance”. Throughout our work, material quality and quality control level has been applied in accordance with the standards mentioned by staying connected to our TS EN 206 - 14 and TS 13515 - 14 concrete standards in order to be able to obtain high strength concrete.

2. The Effect Of The Mineral Additives On Strength And Bindingness

Artificial mineral additives are materials with pozzolanic features due to their content, and which cannot provide a sufficient level of bindingness alone. Evaluating on the basis of oxides, they do not have the same binding power despite the fact that their content is quite similar to that of cement. The reason for this is that hydration cannot continue arising from the disproportion of the oxides contained in their content and that its binding components are not in a sufficient amount. In order calcium silica hydrate (C-S-H) which is the basic binding to be generated, “CaO/SiO_2 should not be < 2,0”. When the Table 3 in which the mineral additive contents are given is examined, it is seen that the value of CaO/SiO2 is 0,77 even in MBFS which is the richest mineral additive in terms of CaO. The mineral additives which cannot provide sufficient amount of CaO on their own in order to generate calcium silica hydrate, provide the required CaO and H_2O gain over Ca(OH)2 created by CaO, released from the dissolution as a result of uniting with hydration with Ca $(OH)_2$ created as a result of cement hydration, with H_2O over time. Thanks to this, $Ca(OH)_2$ amount in the concreate decrease, and the C-S-H rate increases. Joining mechanism of mineral admixtures to bindingness is as given below.

➔ <u>The creation of C-S-H and $Ca(OH)_2$ crystals as a result of cement hydration;</u>



➔ The creation of C-S-H and other hydrate crystals as a result of reaction of the reactive oxides with $Ca(OH)_2$;

$$3[Ca(OH)_2] + 2[SiO_2] \rightarrow [\underbrace{3(CaO).2(SiO_2).3(H_2O)}_{\text{C-S-H (Tobermorite)}}]$$

$$2[Ca(OH)_2] + [SiO_2] \rightarrow [\underbrace{2(CaO).(SiO_2).2(H_2O)}_{\text{C-S-H (Tobermorite)}}]$$

$$3[Ca(OH)_2] + Al_2O_3 + 3[H_2O] \rightarrow [\underbrace{3(CaO).Al_2O_3.6(H_2O)}_{\text{C-A-H (Calcium-Alumina Hydrate)}}]$$

$$4[Ca(OH)_2] + Al_2O_3 + Fe_2O_3 + 4[H_2O] \rightarrow [\underbrace{4(CaO).Al_2O_3.Fe_2O_3.8(H_2O)}_{\text{C-AF-H (Calcium Alumino - Ferrite Hydrate)}}]$$

In the concretes in which mineral additive activity has been completed theoretically, there is a decrease in $Ca(OH)_2$ amount, and an increase in the amounts of C-S-H, C-A-H and C-AF-H compounds. Even though the binding and resistance values of the C-A-H and C-AF-H compounds are not as strong as C-S-H, they are quite plenty compared to $Ca(OH)_2$. As a result of the completed reactions, the resistance values of the concretes produced by using mineral additives may turn out to be higher compared to concretes produced by only cement. However, it is difficult to say anything definite in terms of the speed of resistance gaining. The reason for this is that, the hydration speed is different according to the combination generated by the binding materials used and the physical properties of materials.

3. EXPERIMENTAL STUDY

3.1 Materials

3.1.1 Aggregate

Location	: Feruz, Ankara
Type	: Basalt (Massive, Mafic)
Conformity	: TS 706 EN 12620 +A1
D_{max}	: 16 mm

Physical Properties;

Specific Gravity (gr/cm^3)	: 2,91
Hardness (Mohs)	: 6,5
Wear (Los A. 500 Cycle, %)	: 5,0
Water Absorption (By weight %)	: 0,7

3.1.2 Chemical Additive

Type	: İKSA Polycar 300 - Hyper plasticizer
Conformity	: TS EN 450 – 1

3.1.3 Mineral Additive

I. Type Mineral Additive : Fly Ash - (Çayırhan, Ankara)
Type : Class F. [27]
Conformity : TS EN 450 – 1
II. Type Mineral Additive : Milled Blast Furnace Slag - (Payas, Hatay)
Type : Class 80. [28]
Conformity : TS EN 15167 – 1
III. Type Mineral Additive : Silica Fume - (Dubai, UAE)
Type : 1st Class. [29]
Conformity : TS EN 13263 - 1 +A1

Table 1 : The chemical composition of mineral admixtures.

Chemical Composition		M.B.F. Slag	Fly Ash	Silica Fume
SiO_2	(%)	44,1	50,98	96,1
Al2O3	(%)	10,7	13,11	0,2
Fe_2O_3	(%)	-	9,74	0,6
CaO	(%)	34,1	11,82	0,2
MgO	(%)	6,3	3,87	0,1
Na_2O	(%)	-	2,71	-
K_2O	(%)	0,7	1,91	0,3
SO_3	(%)	Sulphur (S) : 0,4	3,94	-
FeO	(%)	0,3	-	-
TiO_2	(%)	0,5	-	-
Cl^-	(%)	-	0,01	-
Loss On Ignition	(%)	0,04	0,86	1,81
Insoluble Remains	(%)	1,45	2,10	1,1

Table 2 : Physical properties of the mineral additives.

Physical Properties		M.B.F. Slag	Fly Ash	Silica Fume
Specific Gravity	(gr/cm^3)	2,82	2,34	2,25
Specific Surface Area	(cm^2/gr)	4147	2758	233600
0,045 mm Remains Retained in Screen	(%)	8,70	29,0	0,58
7-Day Activity	(%)	54	61	93
28-Day Activity	(%)	81	84	>100

3.1.4 Cement

Type : CEM I 42,5R Cement
Conformity : TS EN 197-1

Table 3 : Physical properties of CEM I 42,5R cement.

Physical Properties		**CEM I 42,5R**
Specific Gravity	(gr/cm^3)	3,10
Specific Surface (Blaine)	(cm^2/gr)	3556
0,045 mm Remains Retained in Screen	(%)	2,1
0,090 mm Remains Retained in Screen	(%)	0,3
2-Day Pressure Resistance	(N/mm^2)	28,8
28-Day Pressure Resistance	(N/mm^2)	56,0

3.2 Mineral Admixtures Usage Experiments

In the experimental studies, the cement dosage has been determined as 500 kg/m3 and the largest water/Binder ratio as 0,30 in order to be able to achieve the required high resistance. The mineral additives have been substituted into the admixture; with increases of 5 % in fly ash, 5 % in milled granulated blast furnace slag and 2 % silica fume. Usage top limits of the mineral additives have been limited in such a way that is compliant with the TS EN 206 -14 and TS 13515 standards. These limits are listed below.

Table 4 : Samples produced using fly ash

Sample Code	**Amount of Usage (Kg/m^3)**				**Water/Binder**
	Cement	**Fly Ash**	**Chemical Additives**	**Water**	
Reference -1	500	0	17,0	91,5	0,20
K1	475	25	17,0	88,5	0,20
K2	450	50	17,0	85,5	0,20
K3	425	75	17,0	82,5	0,20
K4	400	100	17,0	79,5	0,20

K5	375	125	17,0	76,5	0,20
Reference - 2	500	0	12,0	119,0	0,25
K6	475	25	12,0	115,0	0,25
K7	450	50	12,0	111,0	0,25
K8	425	75	12,0	108,0	0,25
K9	400	100	12,0	104,0	0,25
K10	375	125	12,0	100,0	0,25
Reference - 3	500	0	6,0	147,0	0,30
K11	475	25	6,0	142,5	0,30
K12	450	50	6,0	138.0	0,30
K13	425	75	6,0	133,5	0,30
K14	400	100	6,0	129,0	0,30
K15	375	125	6,0	124,5	0,30

Table 5 : Test results of the samples produced using fly ash

Sample Code	**Compressive Strength (MPa)**					**Standard Deviation (MPa)***	**Elasticity Modulus (GPa)***
	2 (Days)	**7 (Days)**	**28 (Days)***	**56 (Days)**	**90 (Days)**		
Reference - 1	45,1	67,1	95,1	98,2	101,3	0,9	40,59
K1	44,6	65,7	95,5	102,1	105,7	1,9	40,46
K2	41,1	60,4	96,4	106,0	110,3	2,1	40,72
K3	39,7	57,0	92,2	111,2	119,5	1,7	39,49
K4	33,4	50,4	88,8	103,7	116,3	2,4	38,98

K5	29,2	46,2	85,0	104,5	120,7	1,5	38,50
Reference - 2	38,6	58,0	80,1	84,5	87,2	0,5	37,43
K6	36,1	56,8	81,6	86,1	90,4	1,6	37,67
K7	31,6	51,2	83,5	92,1	98,5	2,2	37,81
K8	29,2	46,3	83,2	90,5	99,9	1,4	38,02
K9	26,5	40,1	77,1	93,6	103,3	1,6	37,23
K10	23,0	37,2	71,1	90,7	104,0	1,2	36,20
Reference - 3	34,2	51,9	63,3	69,9	70,2	1,2	33,81
K11	34,0	48,4	64,6	73,4	75,2	1,6	34,08
K12	30,6	43,2	67,2	77,1	80,2	2,2	34,37
K13	26,2	38,6	60,2	74,5	81,2	2,9	33,94
K14	21,9	32,6	54,4	75,6	85,2	1,4	32,79
K15	20,4	31,7	52,6	75,1	89,5	1,9	32,91

(*) sign, it means the day of the results of this test.

Table 6 : Samples produced using milled blast furnace slag

Sample Code	**Amount of Usage (Kg/m^3)**				**Water/Binder**
	Cement	**M.B.F. Slag**	**Chemical Additives**	**Water**	
Reference -1	500	0	17,0	91,5	0,20
K16	475	25	17,0	90,5	0,20
K17	450	50	17,0	89,5	0,20
K18	425	75	17,0	88,5	0,20
K19	400	100	17,0	87,5	0,20
K20	375	125	17,0	86,5	0,20
K21	350	150	17,0	85,5	0,20
K22	325	175	17,0	84,5	0,20
K23	300	200	17,0	83,5	0,20
K24	275	225	17,0	82,5	0,20

K25	250	250	17,0	81,5	0,20
Reference - 2	500	0	12,0	119,0	0,25
K26	475	25	12,0	118,0	0,25
K27	450	50	12,0	116,5	0,25
K28	425	75	12,0	115,0	0,25
K29	400	100	12,0	114,0	0,25
K30	375	125	12,0	113,0	0,25
K31	350	150	12,0	111,5	0,25
K32	325	175	12,0	110,0	0,25
K33	300	200	12,0	109,0	0,25
K34	275	225	12,0	108,0	0,25
K35	250	250	12,0	106,5	0,25
Reference - 3	500	0	6,0	147,0	0,30
K36	475	25	6,0	145,5	0,30
K37	450	50	6,0	144,0	0,30
K38	425	75	6,0	142,5	0,30
K39	400	100	6,0	141,0	0,30
K40	375	125	6,0	139,5	0,30
K41	350	150	6,0	138,0	0,30
K42	325	175	6,0	136,5	0,30
K43	300	200	6,0	135,0	0,30
K44	275	225	6,0	133,5	0,30
K45	250	250	6,0	132,0	0,30

Table 7 : Test results of the samples produced using milled blast furnace slag

Sample Code	**Compressive Strength (MPa)**					**Standard Deviation (MPa)***	**Elasticity Modulus (GPa)***
	2 (Days)	**7 (Days)**	**28 (Days)***	**56 (Days)**	**90 (Days)**		
Reference - 1	45,1	67,1	95,1	98,2	101,3	0,9	41,22
K16	44,8	65,5	97,8	101,6	105,4	0,8	41,78
K17	43,2	62,6	101,4	106,3	110,7	0,6	42,00
K18	39,7	60,2	103,2	110,9	118,1	1,7	42,17
K19	37,4	56,3	107,9	115,0	123,5	1,2	42,52
K20	34,2	52,2	104,0	116,5	124,2	2,4	42,47
K21	32,6	49,6	100,3	119,1	129,2	1,7	41,79
K22	32,4	47,8	92,2	117,3	131,6	2,6	39,93
K23	29,9	42,3	86,7	112,2	129,0	2,1	38,72

K24	24,3	38,4	78,4	105,6	123,8	1,9	37,03
K25	23,3	35,9	73,5	98,8	119,4	2,4	36,16
Reference - 2	38,6	58,0	80,1	84,5	87,2	0,5	37,43
K26	38,2	57,2	82,0	89,2	93,5	1,4	37,94
K27	36,1	54,1	86,9	90,6	96,0	1,7	38,84
K28	33,4	51,9	90,2	93,2	102,1	1,2	39,45
K29	31,9	50,5	93,6	98,5	107,5	1,1	40,06
K30	30,0	48,2	95,1	105,7	114,0	1,9	40,23
K31	29,2	46,2	91,3	110,2	121,5	2,0	39,77
K32	25,2	41,6	85,0	106,4	118,8	1,6	38,70
K33	22,7	36,2	81,1	100,0	112,9	1,0	37,88
K34	21,3	35,1	72,7	95,1	110,9	1,9	36,49
K35	20,1	30,7	65,4	88,0	105,6	2,1	34,66
Reference - 3	34,2	51,9	63,3	69,9	70,2	1,2	33,81
K36	33,9	50,7	66,3	71,1	75,2	2,3	34,47
K37	33,2	50,0	71,5	78,7	81,4	1,9	35,87
K38	33,6	47,9	73,0	81,4	87,9	3,1	35,89
K39	30,8	43,9	78,2	88,8	97,3	1,9	36,73
K40	29,4	42,7	70,6	90,1	98,5	2,1	35,67
K41	25,2	40,6	67,7	88,4	99,1	2,4	35,01
K42	26,7	36,1	62,9	85,8	99,8	2,8	34,83
K43	22,2	34,1	58,2	81,5	96,0	3,1	33,54
K44	19,8	30,4	54,4	79,0	95,1	2,9	32,29
K45	18,2	27,6	51,5	73,1	91,1	3,5	31,19

Table 8 : Samples produced using silica fume

Sample Code	**Amount of Usage (Kg/m^3)**				**Water/Binder**
	Cement	**Silica Fume**	**Chemical Additives**	**Water**	
Reference -1	500	0	17,0	91,5	0,20
K46	490	10	17,0	93,5	0,20
K47	480	20	17,0	95,5	0,20
K48	470	30	17,0	97,5	0,20

K49	460	40	17,0	99,5	0,20
K50	450	50	17,0	101,5	0,20
Reference - 2	500	0	12,0	120,0	0,25
K51	490	10	12,0	121,5	0,25
K52	480	20	12,0	124,0	0,25
K53	470	30	12,0	126,5	0,25
K54	460	40	12,0	129,0	0,25
K55	450	50	12,0	131,5	0,25
Reference - 3	500	0	6,0	147,0	0,30
K56	490	10	6,0	150,0	0,30
K57	480	20	6,0	153,0	0,30
K58	470	30	6,0	156,0	0,30
K59	460	40	6,0	159,0	0,30
K60	450	50	6,0	162,0	0,30

Table 9 : Test results of the samples produced using silica fume

Sample Code	**Compressive Strength (MPa)**					**Standard Deviation (MPa)***	**Elasticity Modulus (GPa)***
	2 (Days)	**7 (Days)**	**28 (Days)***	**56 (Days)**	**90 (Days)**		
Reference - 1	45,1	67,1	95,1	98,2	101,3	0,9	41,22
K46	45,4	67,9	96,0	101,3	105,2	1,5	41,18
K47	45,2	69,2	99,6	104,0	108,3	1,1	41,96
K48	44,4	70,3	103,3	108,1	111,7	2,2	43,14

K49	43,7	71,6	106,2	110,9	112,5	3,0	43,76
K50	42,1	73,1	108,4	114,2	117,6	2,1	44,05
Reference - 2	38,6	58,0	80,1	84,5	87,2	0,5	37,43
K51	37,1	60,2	83,6	88,2	90,2	1,9	38,45
K52	36,8	61,7	85,1	91,5	94,7	2,1	39,21
K53	34,7	65,2	86,8	93,8	96,3	1,4	39,08
K54	34,5	68,0	90,3	97,9	101,3	1,8	40,13
K55	33,1	69,1	93,9	99,6	104,0	2,3	40,63
Reference - 3	34,2	51,9	63,3	69,9	70,2	1,2	33,81
K56	34,4	54,6	64,6	73,2	75,2	1,6	34,65
K57	34,9	57,2	68,2	75,7	81,4	0,7	35,03
K58	33,6	57,7	73,9	79,2	86,2	1,5	36,70
K59	33,0	60,5	76,7	82,4	87,3	2,0	37,07
K60	31,2	62,1	78,4	89,2	91,4	1,3	37,71

(*) sign, it means the day of the results of this test.

The limit value for fly ash: "the maximum amount of fly ash that will be used together with CEM I cement" included in the (2) article of the headline " k-value for the fly ash that is compliant with 5.2.5.2.2 EN 450-1" of TS 13515 standard must provide the condition given below: (Fly ash / cement) ≤ 0,33 (as mass)".[6a]

The limit value for ground granulated blast furnace slag: When "Annex L" section of TS EN 206 - 14 standard is examined, this expression is seen in an article (7); "the maximum amount of ground granulated blast furnace slag: (as mass) ground blast furnace slag/cement ≤ 1,0". This expression is valid for CEM I cement.[6b]

The limit value for Silica fume: "the maximum amount of Class 1 Silica smoke that will be taken into consideration must meet the following requirement: (Silica fume/cement) ≤ 0,11 (as mass)" included in the article (2). of the headline "k-value for the class 1 silica fume that is compliant with 5.2.5.2.3 EN 13263-1" of the TS 13515 standard. This expression is valid for CEM I cement.[7]

When Table 4 is examined, it is seen that fly ash/cement (as mass) rate of the K5, K10, and K15 samples is 0,333. However, it is seen that this situation provides the requirement of tolerance value "± %3" for the acceptable mineral additive usage error for high strength concretes included in the section "Chart 27" of the TS EN 206 - 14 standard. The same situation is also valid for the K50, K55, K60 admixtures produced by using silica fume.

4. ASSESSMENT OF THE EXPERIMENT RESULTS

4.1 Assessment of the Admixture Results with Fly Ash Substitute

In concretes with high strength, class F fly ash used by switching with cement in certain ratios within the measurements allowed by our standards;

→ When it is used up to 10%, it reduces the 2 and 7-day resistances of the prepared samples compared to the witness samples (replicate samples), however, increases the 28+ day final resistance strengths to higher levels.

→ 2, 7 and 28-day fly ash usage in a rate of %15-25 reduces the resistances of the prepared samples compared to the witness samples (replicate samples), however this situation changes in 56+ day resistances, and reaches higher levels compared to the witness samples (replicate samples).

→ The effect of the general resistance gain of the fly ash in 0.20, 0.25 and 0.30 water/binder rates does not change and provides compliance to the first two articles above.

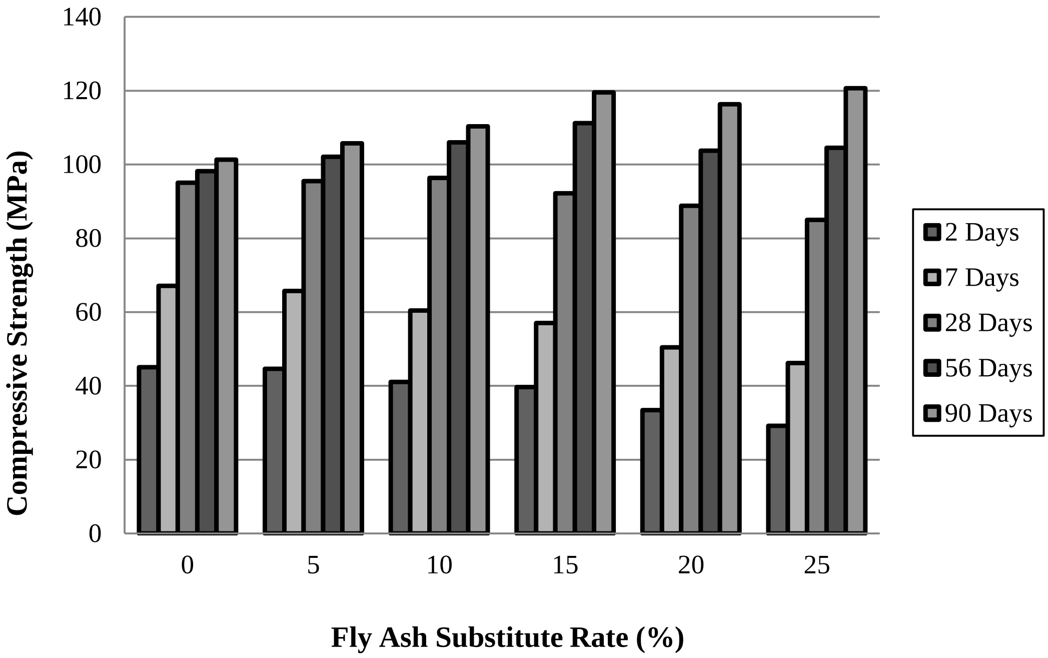


Figure 1 : Time-dependent variation of pressure resistance of the fly ash substitutes samples with a water/binder ration of 0,20.

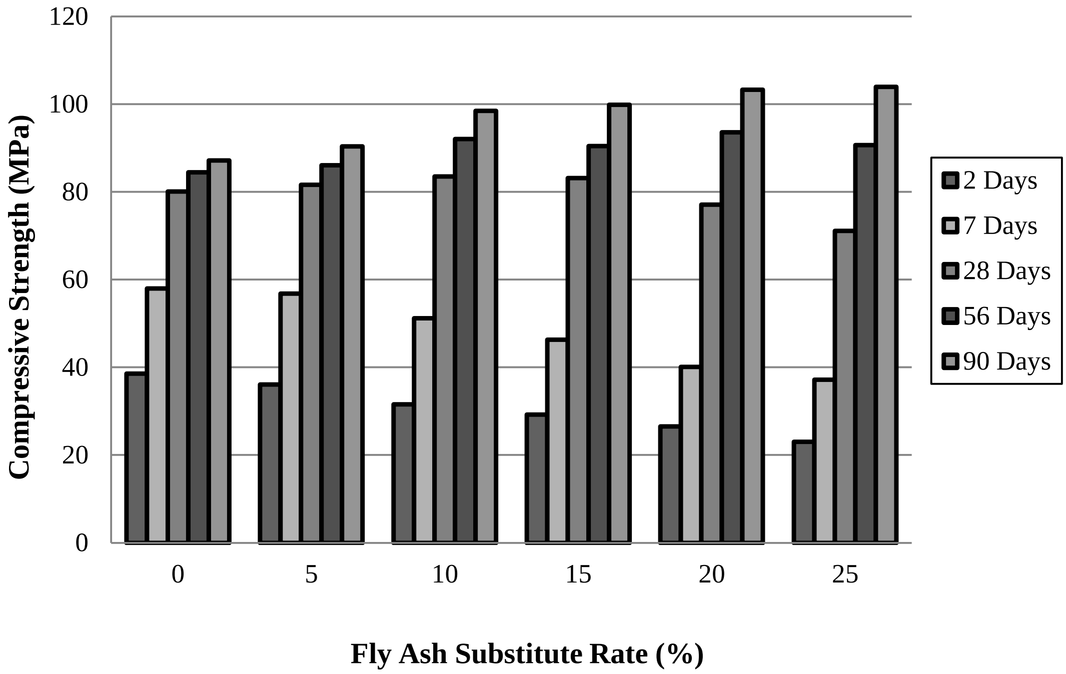


Figure 2: Time-dependent variation of pressure resistance of the fly ash substitutes samples with a water/binder ration of 0,25.

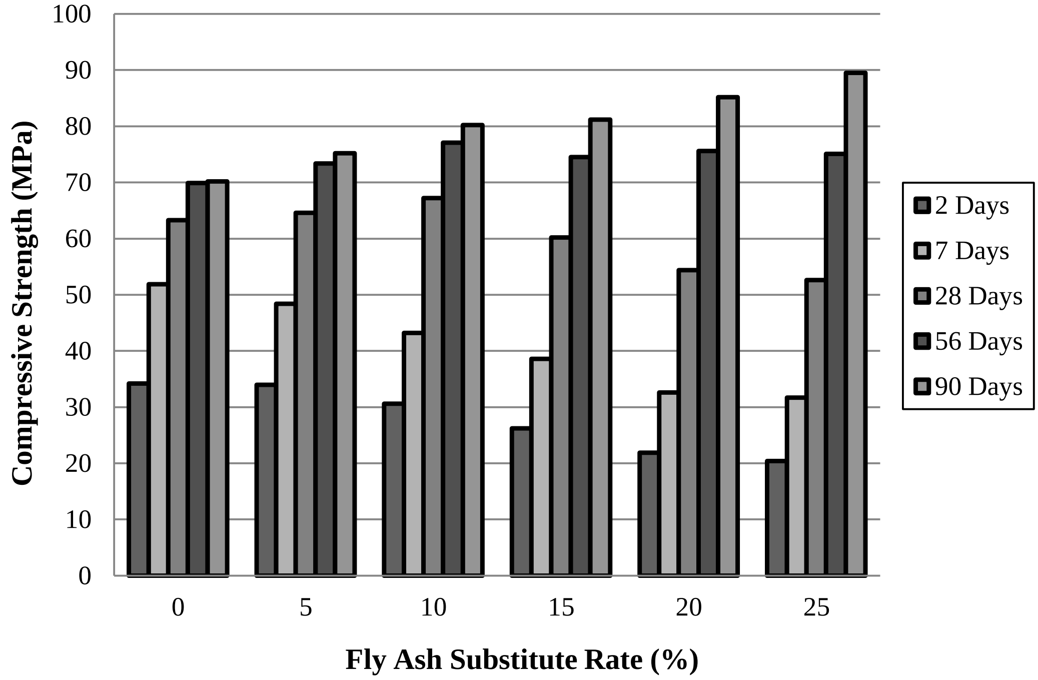


Figure 3: Time-dependent variation of pressure resistance of the fly ash substitutes samples with a water/binder ration of 0,30.

4.2 Assessment of the Admixture Results with Milled Blast Furnace Slag Substitute

In concretes with high strength, class 80 Milled Blast Furnace Slag used by switching with cement in certain ratios within the measurements allowed by our standards;

→ When it is used up to 30%, it reduces the 2 and 7-day resistances of the prepared samples compared to the witness samples (replicate samples), however, increases the 28+ day final resistance strengths to higher levels.
→ 2, 7 and 28-day fly ash usage in a rate of %35-50 reduces the resistances of the prepared samples compared to the witness samples (replicate samples), however this reaches higher levels in 56+ day resistances.
→ The effect of the general resistance gain of the milled blast furnace slag (MBFS) in 0.20, 0.25 and 0.30 water/binder rates does not change and provides compliance to the first two articles above.
→ Milled blast furnace slag, because it contains up to 35% CaO, the mixture is used instead of cement into offers up to 30% higher compared to the reference values in the 28-day compressive strength.

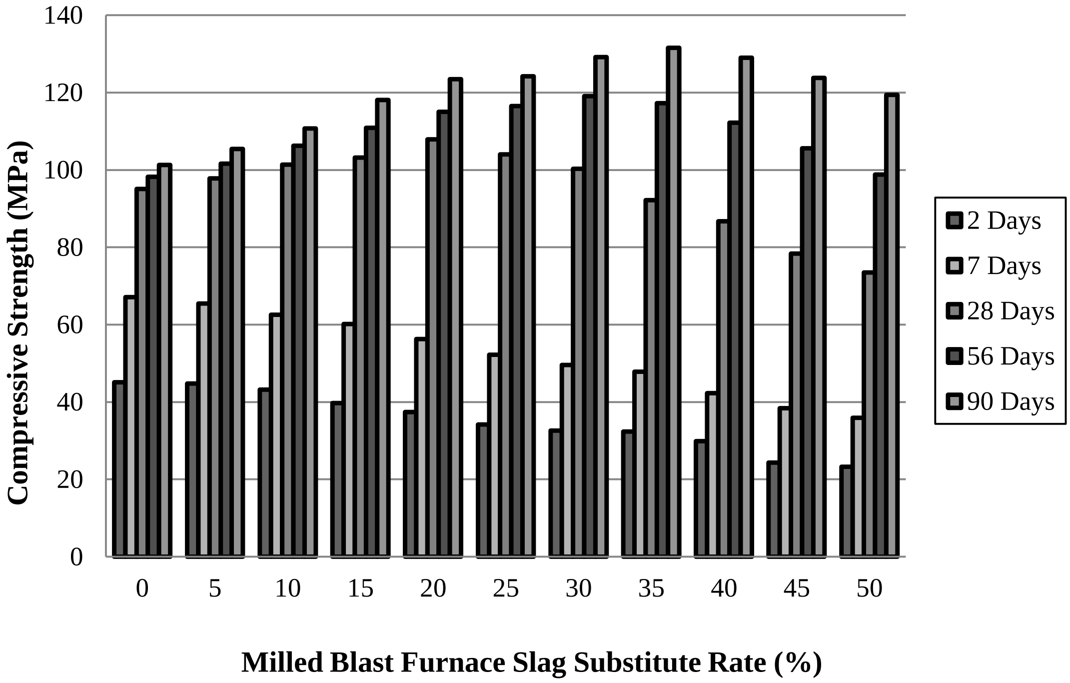


Figure 4: Time-dependent variation of pressure resistance of the milled blast furnace slag substitutes samples with a water/binder ration of 0,20.

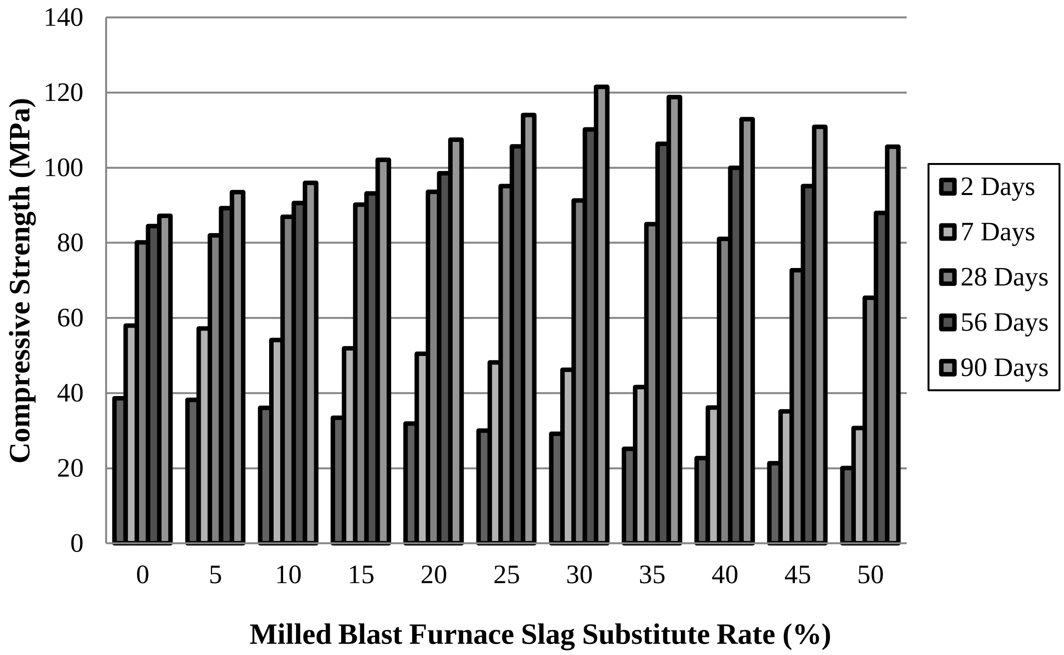


Figure 5: Time-dependent variation of pressure resistance of the milled blast furnace slag substitutes samples with a water/binder ration of 0,25.

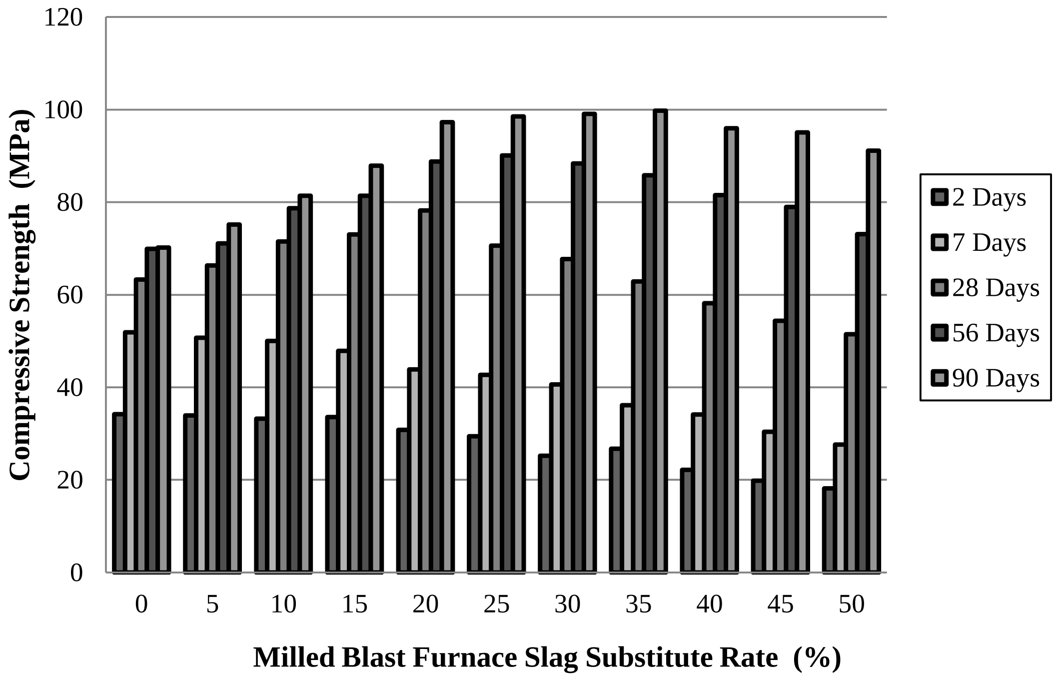


Figure 6: Time-dependent variation of pressure resistance of the milled blast furnace slag substitutes samples with a water/binder ration of 0,30.

4.3 Assessment of the Admixture Results with Silica Fume Substitute

In concretes with high strength, 1st class silica fume used by switching with cement in certain ratios within the measurements allowed by our standards;

→ When it is used up to 10%, it reduces only the 2-day resistances of the prepared samples compared to the witness samples (replicate samples), however, increases the 7+ day final resistance strengths compared to the witness samples to higher levels.
→ The effect of the 0.20, 0.25 and 0.30 water/binder rates of silica fume usage on the general resistance gain do not change, and provides compliance with the first article above.
→ The silica fume (Silica fume / cement) ≤ 0.11 (as mass) utilization rate , the reason for giving strength loss early age , a high proportion of SiO_2 , and that the surface area of the silica fume is thought to be due to very large. High levels of SiO2 , a significant increase in the rate of pozzolanic reaction resulting from C- S- H gel constitute . C- S- H in the mixture of the increase of the gel, provides a higher compressive strength is obtained.
→ Silica fume is very high surface area , at an early age in the concrete mix provides to contribute to the show pozzolanic reaction and compressive strength .

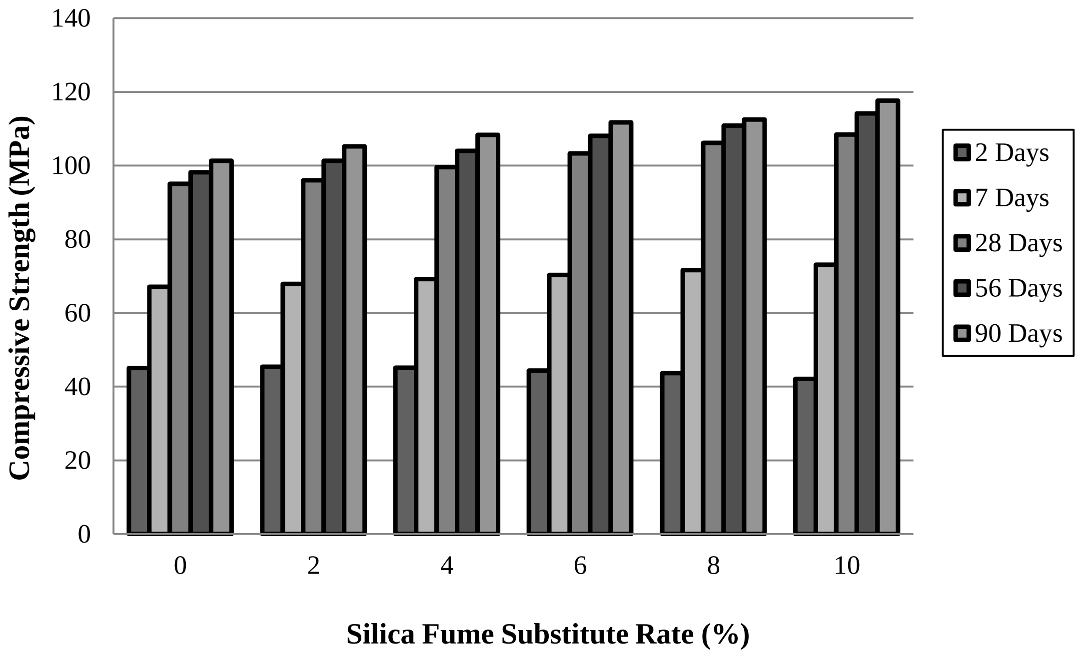


Figure 7: Time-dependent variation of pressure resistance of the silica fume substitutes samples with a water/binder ration of 0,20.

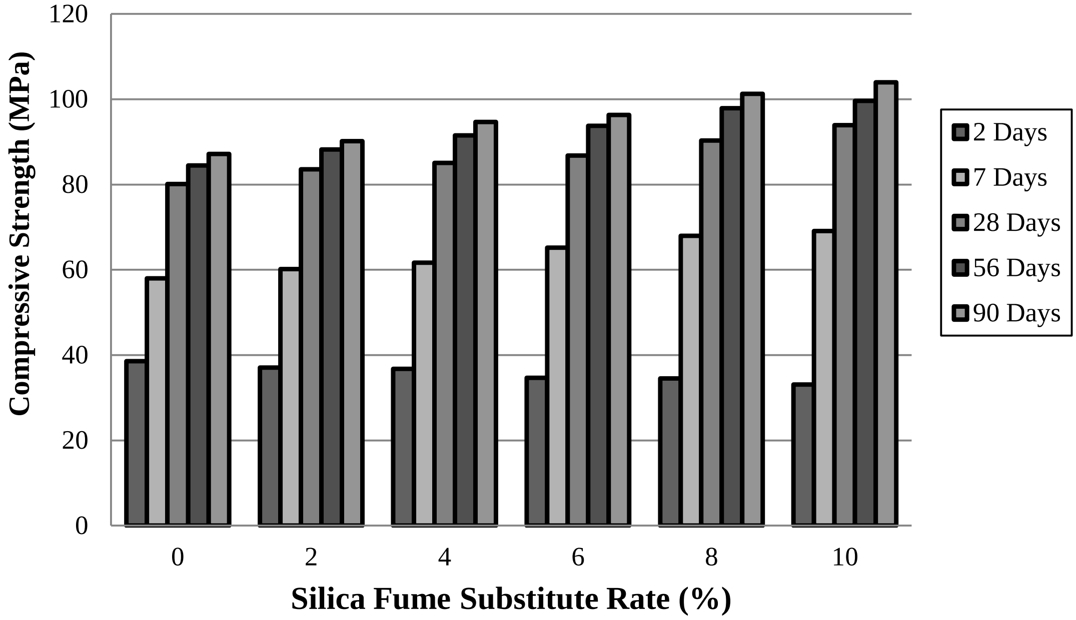


Figure 8: Time-dependent variation of pressure resistance of the silica fume substitutes samples with a water/binder ration of 0,25.

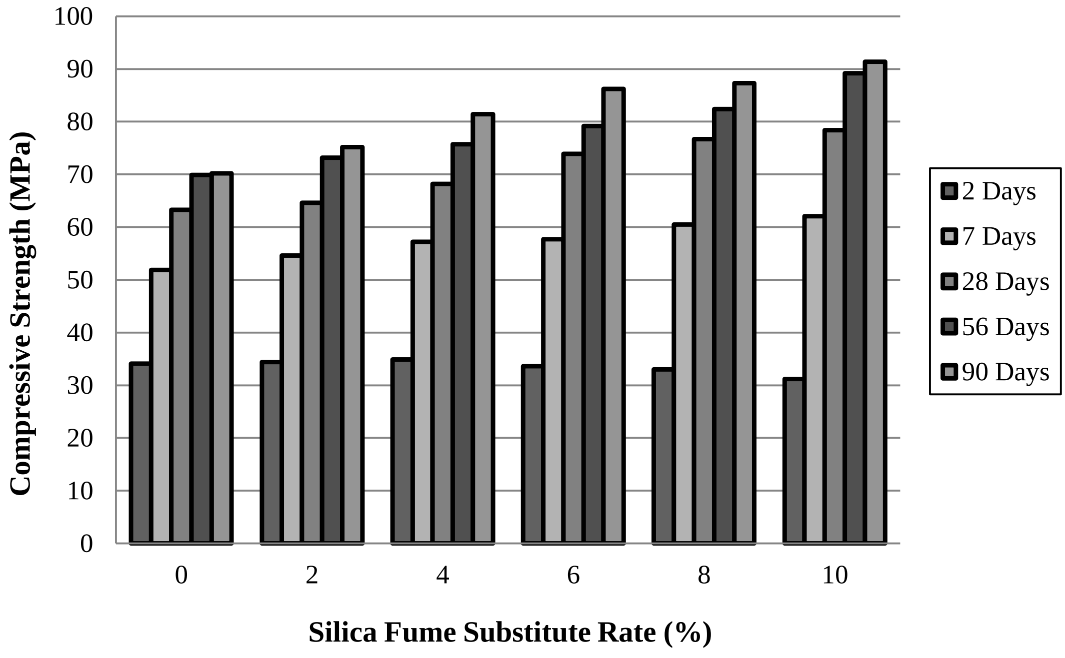


Figure 9: Time-dependent variation of pressure resistance of the silica fume substitutes samples with a water/binder ration of 0,30.

5. RESULTS AND RECOMMENDATIONS

It is seen that, remaining in the limit values of the material amounts (mineral additives, chemical additives) of the TS EN 206-14 and TS 13515 standards we already use, complying with the specified quantity in material usage and quality control levels, it is possible to produce high-strength concrete with resistances such as 73.1 MPa, 108.4 MPa, 119.1 MPa, 131.6 MPa respectively in 7, 28, 56 and 90-day 100x100x100mm cube strengths. In particular, it is possible to carry these figures to higher levels by reducing the D_{max} value and increasing the amount of binder material. Mineral additives increase the $Ca(OH)_2$ amount in the concrete, and enables the concrete to become more stable and to display outstanding resistance properties against external effects. The contents of the admixtures prepared within the framework of the experiments have been analyzed in the "Life-365" program, and it has been observed that in the HSC with water/binder $\leq$ 0,30, mineral additive usage up to 35% is able to lengthen the concrete service life up to 60% under ideal conditions. Other benefits of mineral additive usage apart from the mechanical properties of the high strength concretes have been listed below;

- The fact that they are industrial wastes each and their being consumed by being used in high strength concretes is of great importance in terms of the concept of "Sustainability".
- By reducing the amount of cement needed, by reducing the CO_2 emissions arising from the production of cement and the consumption of raw materials, benefits are obtained to a great extent in terms of ecological balance.
- Their being used without being stored gives rise to a great economic and ecological profit in terms of their disposal.
- Their reducing the need for cement offers a plus the advantage economically.

Based on the test results and the information provided, mineral additive usage by replacing with the appropriate amount of cement in normal and high-strength concrete is recommended by the authors. Experimental studies should be done and the results should be evaluated before using mineral additives.

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