Journal of Structural Engineering and Geotechnics,

5 (2), 51-58, Spring 2015

The Effect of Recurring on Physical Properties of Concrete Containing Silica-Fume with Improper First Curing

Ali Delnavaz[*a], Mohammad Reza Pezeshkian[b]

[a]*Department of civil and surveying engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran*

[b]*Department of mechanical engineering, Takestan Branch, Islamic Azad University, Takestan, Iran*

Received 20 March 2015, Accepted 7 May 2015

Abstract

As regards if curing stops for some time and then resumes again, then strength gain will also stop and reactive, in this study with choose suitable curing conditions after improper first curing (recurring) for normal and silica-fume concrete, Effect of this curing conditions on strength and permeability was investigated. The results from tests such as compressive strength, capillary water absorption and water penetration under pressure, indicates that curing after 28 days for concretes with improper first curing, especially for silica-fume concretes could be effective and reduction permeability and increase compressive strength of concretes was observed

Keywords: Recurring, Silica-fume, Compressive strength, Water penetration under pressure, Capillary Absorption

1- Introduction

Curing is the process of controlling the rate of moisture loss from concrete during cement hydration. In order to obtain good quality concrete, an appropriate mix must be followed by curing in a suitable environment during the early stages of hardening [1, 2] Curing encompasses the control of temperature as it affects the hydration rate in cement. If, within the curing period, natural temperatures of concrete are in the acceptable range of values, only the moisture content needs to be controlled. [3, 4]

The hydration of cement virtually ceases when the relative humidity within capillaries drops below 80% and under an efficient curing method such as water curing, the relative humidity is maintained above 80% to continue the hydration of cement. [5]

If a concrete is not well cured, particularly at the early age, it will not gain the properties and durability at desired level due to a lower degree of hydration, and would suffer from irreparable loss [6, 7]. If a concrete is not cured at the early age, it cannot gain the properties and durability for its long service life. A proper curing greatly contributes to reduce the porosity and drying shrinkage of concrete, and thus to achieve higher strength and greater resistance to physical or chemical attacks in aggressive environments [8].

As regards If curing stops for some time and then resumes again, then strength gain will also stop and reactivate [9]; though the detrimental effect of early improper curing are irreversible, in this study the effect of recurring on strength and permeability of ordinary concrete and concretes containing silica-fume is investigated. For this purpose, different curing conditions choose and concrete compressive strength and permeability was studied in these conditions.

2- Experimental program

2-1 Materials

Type II Portland cement (OPC) was used for this study. The compositions of the used OPC are given in table 1.

Table1. Composition of OPC

Oxide type	CaO	SiO2	AL2O3	Fe2O3	MgO	SO_3	Na2O+K2O
Oxide percent (%)	64.5	21	4.6	3.2	2	2.9	1

* Corresponding Author Email: a.delnavaz@qiau.ac.ir

Crushed aggregate with maximum size of 20mm was used as coarse aggregates; natural river bed quartzite sand was used as fine aggregates. The results of the sieve analysis and properties of the aggregates are given in table 2 and table 3 respectively. The fractions of different sizes of crushed granite stone and mining sand were in the ranges specified in ASTM C33 [10]

Table 2: Gradation of crushed granite stone and mining sand

Sieve size	% finer by mass	
	Crushed granite	Mining sand
19 mm	100	100
9.5 mm	25	100
4.75 mm	7	100
2.36 mm	2	85
1.18 mm	0	65
600 μm	0	35
300 μm	0	15
150 μm Type	0	1

Table 3: Properties of aggregates

S.N	Property	Fine Aggregate	Coarse Aggregate
1.	Specific Gravity	2.51	2.71
2.	Fineness Modulus	2.93	6.52
3.	Porosity (%)	42.4	41
4.	Voids ratio	0.71	0.4

Table 4: Physical properties of SF

Specific Mass	2.2
Volume Density($^{kg}/_{m^3}$)	576
Size (Micron)	0.1
Specific Area($^{m^2}/_{kg}$)	20000
SIO_2	%90 - %96
AL_2O_3	%0.5 - %0.8

Silica fume (SF) used in this investigation was conforming to ASTM-C1240 [11] and its properties are shown in table 4.

Potable Water was used in the investigation and polycarboxylic ether based super plasticizer complying with ASTM C-494 [12] type A, were used for attainment required slump in concrete.

2-2 Mix Proportions

In this study 3 w/b ratios (0.45, 0.5 and 0.55) were used and silica-fume was used as a 10% weight replacement of cement. Also aggregates were determined on the basis of absolute volume of the constituents and mining sand was used with a quantity of 40% of total aggregates by weight. The concrete mixture was proportioned to have a minimum slump of 500 mm. Several trial mixtures were prepared to fix the dosages of super plasticizer for concrete, and to judge the acceptability of the mixture composition. The details of mixture proportions are given in Table 5.

2-3 Testing of Fresh Concrete

The fresh concrete was produced using a rotating pan type mixer. Immediately after mixing, the fresh concrete was tested for slump. The slump was determined according to ASTM C143 [13]

Table 5: Mix proportions for concretes without silica-fume (0A, 0B, 0C) and concretes containing silica-fume (10A, 10B, 10C)

Materials / N.C	Gravel (kg/m^3)	Sand (kg/m^3)	Cement (kg/m^3)	W/C	Water (kg/m^3)	Silicafume (kg/m^3)	Superplasticizer (kg/m^3)
0A	1024	746	400	0.45	180	-	-
0B	1024	746	400	0.5	200	-	-
0C	1024	746	400	0.55	220	-	-
10A	1024	746	360	0.45	165	40	15
10B	1024	746	360	0.5	185	40	15
10C	1024	746	360	0.55	205	40	15

2-4 Casting

In the present study standard cylinders of size 200mm height, 100mm diameter for determining the compressive strength and cubes with size 150 x 150 x150mm for water penetration under pressure test and cubes with 100 x 100 x100 mm were used for water absorption test. The cast specimens were remolded at the end of 24±2 hours and applied under different regime of curing.

2-5 Curing conditions

The study was done in 5 different curing condition (In all stages temperature of saturated limewater and laboratory air was constant at 20±2℃). All specimens were tested after 56 days from demoulding.

A) Specimens were submerged in saturated limewater for 28 days thereafter they were exposed to laboratory air for 28 days (This condition was used to proper curing time).

B) Specimens were submerged in saturated limewater for 3 days thereafter they were exposed to laboratory air for 53 days (This condition was used to improper curing time).

C) Specimens were submerged in saturated limewater for 3 days then they were exposed to laboratory air for 25 days then again submerged in saturated limewater for 4 days and finally were exposed to laboratory air for 24 days. (This condition was used to improper first curing and short time curing after it)

D) Specimens were submerged in saturated limewater for 3 days thereafter they were exposed to laboratory air for 25 days then again submerged in saturated limewater for 28 days. (This condition was used to improper first curing and longtime curing after it).

E) Specimens were submerged in saturated limewater for 7 days thereafter they were exposed to laboratory air for 49 days (This condition was used to improper curing time).

3- Tests Results

3-1 Compressive strength test

The compressive strength was determined in accordance with ASTM C39 [14] and cylinders of size 200mm height, 100mm diameter were used. The results for compressive strength have been presented in Table 6.

Table 6: Compressive strength of specimens

Compressive strength (Mpa)	NS**	Compressive strength (Mpa)	N.S*	(W/C)
41.3	A10	33.98	A0	0.45
38.59		31.42		0.5
34.51		27.58		0.55
34.53	B10	30.4	B0	0.45
32.44		28.6		0.5
29.17		25.01		0.55
37.7	C10	31.9	C0	0.45
34.97		28.87		0.5
32.52		24.97		0.55
39.43	D10	32.65	D0	0.45
36.23		29.68		0.5
32.48		25.45		0.55
39.81	E10	33.35	E0	0.45
37.03		30.4		0.5
33.81		27.08		0.55

* A0-E0 Specimens without silica fume under A-E curing conditions
** A10-E10 Specimens contain silica fume under A-E curing conditions

3-2 Water absorption test

This test is used to determine the rate of absorption of water for concrete by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen was exposed to water. In this test, cubes specimens with size 100x100x100 mm placed in the oven at a temperature of 40±5°C and for 14 days. Then record initial weight of specimens. Next Place the support device at the bottom of the pan and fill the pan with tap water so that the water level is 1 to 3 mm above the top of the support device. Maintain the water level 1 to 3 mm above the top of the support device for the duration of the tests. Record the mass at the intervals 3, 6, 24, 72 hours after first contact with water.

The rate of water absorption (mm/$\sqrt{h}$) is defined as the slope of the line that is the best fit to I plotted against the square root of time and shown in table 7

The absorption was defined as:

$$I = \frac{M_i - M_o}{A} \quad (1)$$

$M_i - M_o$ = the change in specimen mass in grams, at the time t,

A= the exposed area of the specimen, in cm^2

Table 7: results of the water absorption test

Rate of water absorption ($mm/\sqrt{h}$)	N.S**	Rate of water absorption ($mm/\sqrt{h}$)	N.S*	(W/C)
0.005	A10	0.008	A0	0.45
0.0052		0.0085		0.5
0.0059		0.0085		0.55
0.0059	B10	0.009	B0	0.45
0.0063		0.0095		00.5
0.0072		0.0095		0.55
0.0051	C10	0.0085	C0	0.45
0.0056		0.0088		0.5
0.006		0.0091		0.55
0.005	D10	0.0084	D0	0.45
0.005		0.00868		0.5
0.0061		0.00885		0.55
0.0052	E10	0.0081	E0	0.45
0.0056		0.0086		0.5
0.006		0.00087		0.55

* A0-E0 Specimens without silica fume under A-E curing conditions
** A10-E10 Specimens contain silica fume under A-E curing conditions

3-3 Water penetration under pressure test

This test is used to determine depth of penetration of water under pressure in accordance with BS EN 12390-8 [15]. Water is applied under 5 bar of pressure for 72h to the surface of hardened cubes concrete with size of 150x150x150 mm. Then specimens were fractured and measured the average seepage depth. This seepage depth was the criteria of the water penetration which are given in table 8.

Table 8: results of the water penetration depth under pressure test

seepage depth (cm)	N.S**	seepage depth (cm)	N.S*	(W/C)
2.2		2.8		0.45
2.8	A10	3.1	A0	0.5
3		3.2		0.55
4.1		5.1		0.45
4.5	B10	5.1	B0	0.5
4.5		5.6		0.55
3.4		3.6		0.45
3.6	C10	4.1	C0	0.5
4.5		4.9		0.55
2.4		3.1		0.45
2.7	D10	3.6	D0	0.5
3.1		3.6		0.55
2.4		2.9		0.45
2.5	E10	3.3	E0	0.5
2.8		3.5		0.55

* A0-E0 Specimens without silica fume under A-E curing conditions
** A10-E10 Specimens contain silica fume under A-E curing conditions

4- RESULTS AND DISCUSSION

4-1 Compressive strength test

The results shown in figure 1 represent percent of increase of compressive strength for specimens with silica-fume compared to specimens without silica-fume. From these results, specimens under curing condition A, B had maximum and minimum percent of increase of compressive strength respectively. Also the results show that percent of increase of compressive strength for Curing condition D is better than E. As a result, 28 days curing after improper first curing was useful and even that was better than 7days first curing for silica-fume concrete.

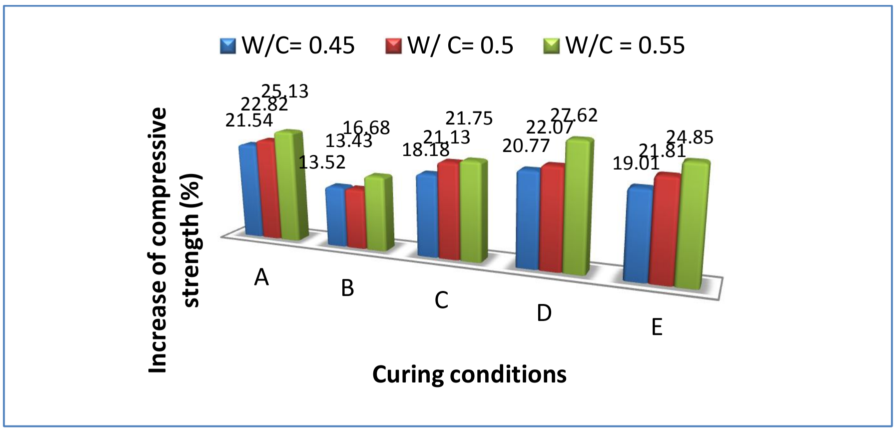

Fig 1: Percent of increase of compressive strength for silica-fume concrete compared to Ordinary concrete under A-E curing conditions

Figure 2 represent the percent of compressive strength for all specimens compared to compressive strength for specimens under curing condition A (specimens were subjected to 28 days first curing condition). This results show that curing condition E (7 days first curing condition) had maximum percent of compressive strength. Also are shown that curing conditions D and C (specimens were subjected to 28 days and 4 days curing after improper first curing. respectively) were useful and show progressive increase in strength.

The results shown in figure 3 represent specimens under curing conditions D and C compared to curing condition B (Specimens with improper first 3 days of curing). The results show that curing after first improper curing was beneficial and for W/C= 0.45 show at least 4.93% and maximum 14.26% increase of strength for ordinary and silica-fume concrete under curing condition C and D respectively. Also these results indicate that curing after first improper curing for silica-fume concrete was more effective than ordinary concrete and silica-fume concrete had greater strength gain than ordinary concrete.

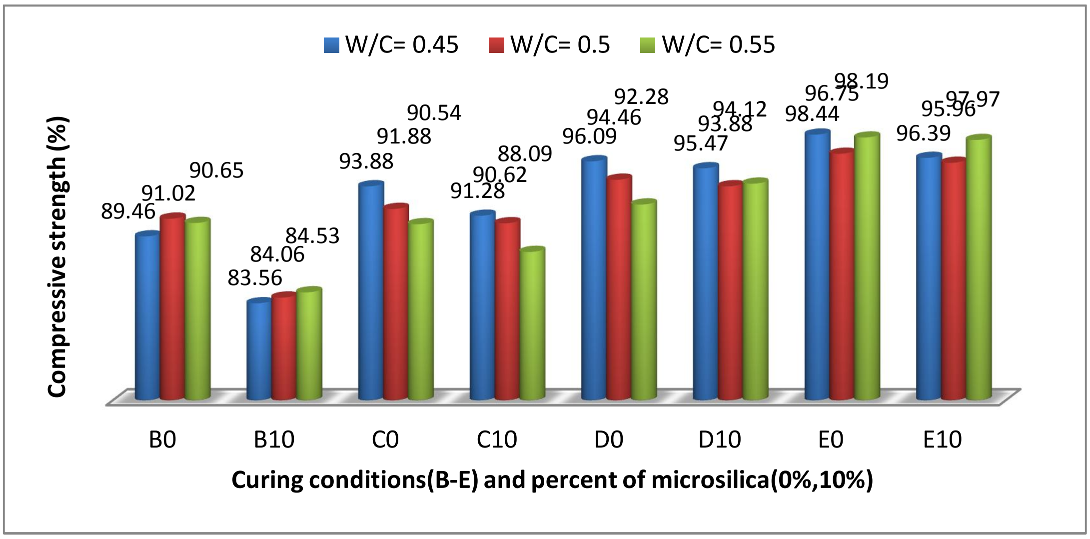

Fig 2: Comparison between percent of compressive strength for all specimens to specimens Under curing condition A

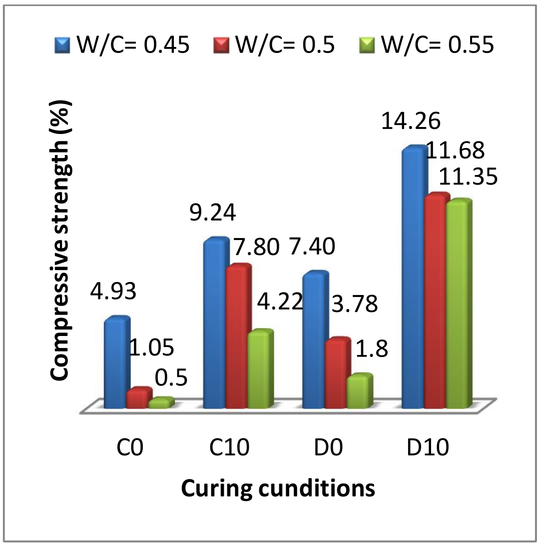

Fig 3: Comparison between percent of compressive strength for specimens Under curing conditions C and D to curing condition B

4-2- Water absorption test

Figure 4 represent the rate of water absorption for ordinary and silica-fume concrete. The results show that specimens under curing conditions A and B had minimum and maximum rate of water absorption respectively. Also curing conditions C and D were effective and they had reduction in permeability compared to B curing condition. These results also show that curing after first improper curing for silica-fume concrete was more effective than ordinary concrete and silica-fume concrete had lower penetration than ordinary concrete.

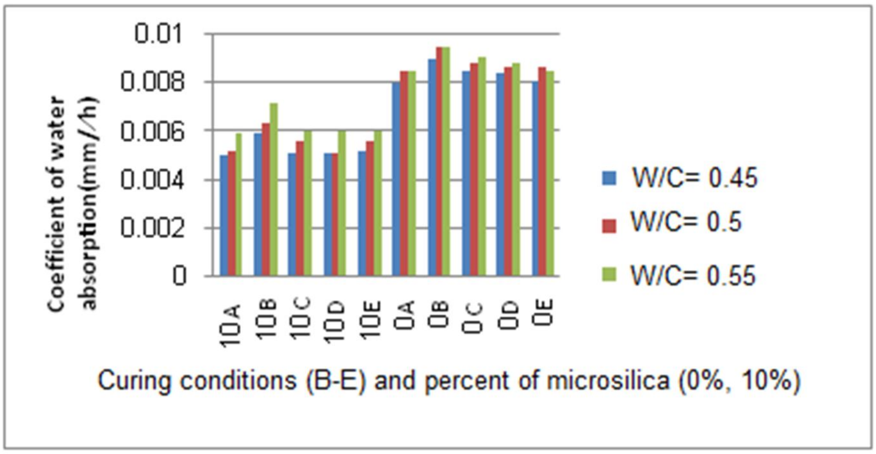

Fig 4: Results for coefficient of water absorption test

4-3- Water penetration under pressure test

Figure 5 show that specimens under curing conditions A had lowest penetration. Also curing conditions C and D were effective and they had reduction in permeability compared to B curing condition. This results show that with increasing of water-cement ratio, Depth of penetration of water into specimens was increased.

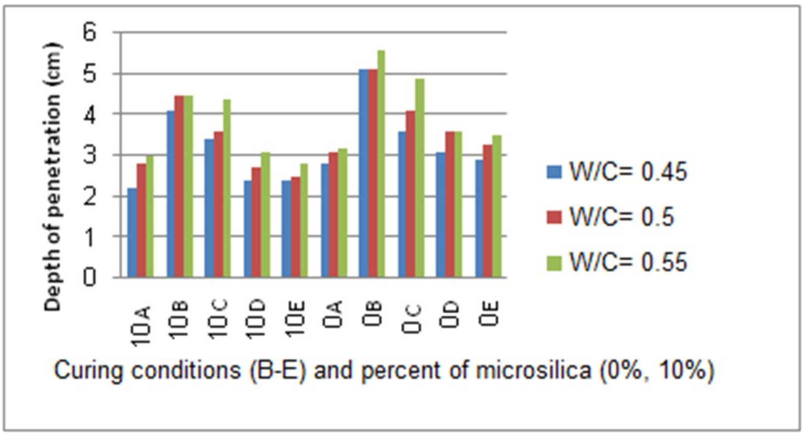

Fig 5: Results of water penetration under pressure test

5. Conclusion

The following conclusions have been drawn from this study:

1) The results from compressive strength test showed that curing after improper first curing was effective and for W/C= 0.45, showed 4.93% , 14.26% increase of strength for ordinary and silica-fume concrete under curing condition C and D respectively.

2) All tests confirmed that curing after 28 days for specimens with improper first curing, was more effective for silica-fume concrete than ordinary concrete and under these conditions silica-fume concrete had lower penetration and higher strength than ordinary concrete.

3) The 56 days compressive strength of silica-fume concrete with 10% silica fume was 20%-25% more than the ordinary concrete. Also results from tests such as water penetration under pressure and water absorption test showed that concrete containing silica-fume had lower penetration than ordinary concrete.

4) Minimum duration for achieve to at least 90% specified strength at 28 days, was 3days and 7days for ordinary and silica-fume concrete respectively.

Acknowledgements

The support for this study was provided by the Civil engineering and construction Research Center of Islamic azad university of Qazvin. The authors are grateful for the help and technical assistance offered by the head of the CCRC, Dr. Reza Farrokhzad.

Reference

[1] Neville. A.M., "Properties of Concrete", 4th Edition, Pitman Publishing Limited, London 1997.

[2] Shetty M.S, "Concrete Technology: Theory and Practice", 23rd Revised edition, S.Chand and Company New Delhi, India.

[3] Soroka, C.H.Jaegermann and A.Bentur, "Short-term steam-curing and concrete later-age strength", Materials and Structures, Springer Netherlands, March, 1978, Vol.11, No.2, pp.93-96.

[4] Standard for Recommended Practice for Measuring, Mixing and Placing Concrete (ACI 614), American Concrete Institute.

[5] Neville, A.M., 1996. Properties of Concrete, Fourth and Final Edition. John Wiley and Sons, Inc., NewYork, USA.

[6] Ramezanianpour, A.A. and V.M. Malhotra, 1995. Effect of Curing on the Compressive Strength, Resistance to Chloride-Ion Penetration and Porosity of Concretes Incorporating Slag, Fly Ash or Silica Fume. Cement and Concrete Composites, 17(2): 125-133.

[7] Zain, M.F.M., M. Safiuddin and K.M. Yusof, 2000. Influence of Different Curing Conditions on the Strength and Durability of High Performance Concrete. In the Proceedings of the Fourth ACI International Conference on Repair, Rehabilitation and Maintenance, ACI SP-193, American Concrete Institute, Farmington Hills, Michigan, USA., pp: 275-292.

[8] M.V. Krishna Rao, P. Rathish Kumar, Azhar M. Khan, 2010, A study on the influence of curing on the strength of a standard grade concrete mix. Architecture and Civil Engineering Vol. 8, No 1

[9] Bushlaibi A. H, Alshamsi A. M. (2002). Efficiency of curing on partially exposed high-strength concrete in hot climate. Cement and concrete research. Vol.32, pp 949-953.

[10] ASTM C33, 1996. Standard Specification for Concrete Aggregates. Annual Book of ASTM Standards, Vol. 04. 02, the American Society for Testing and Materials, Philadelphia, USA.

[11] ASTMC 1240 – 03a. Standard Specification for Use of Silica Fume as a Mineral Admixture Used in Hydraulic-Cement Concrete, Mortar, and Grout Cementitious Mixtures: American Society for Testing and Materials; 2005.

[12] ASTM C-494. Standard Specification for Chemical Admixtures for Concrete :American Society for Testing and Materials; 2003

[13] ASTM C143, 1996. Standard Test Method for Slump in Hydraulic Cement Concrete. Annual Book of ASTM Standards, Vol.04.02, The American Society for Testing and Materials, Philadelphia, USA.

[14] ASTM C 39/C 39M – 03. Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens: American Society for Testing and Materials; 2005.

[15] BS EN 12390-8,Testing hardened concrete. Depth of penetration of water under pressure. standard publishe by British-Adopte European Standard:2000