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Effect of Silica Fume and Polymers on Absorption and Some Mechanical Properties of Concrete Contains Waste Aggregates

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Abstract. This research aims to study the effect of silica fume and polymers (Styrene Butadiene Rubber (SBR)) on absorption and some mechanical properties of concrete like compressive, tensile and flexural strength of concrete containing waste aggregates. The reference mixes having waste aggregates (crushed glass) as coarse aggregates to decrease cost of concrete and also increase strength.
The effect of silica fume only on concrete was give 61% increment in compressive strength, but with polymers together give about 72% increment, flexural strength increased from 3.8 MPa for reference mixes to 10.5 MPa for silica fume mixes and 12.3 MPa for polymer-silica mixes. The absorption decreases from 6.01% to 2.85% for silica mixes and to 1.5% for polymer-silica mixes.

Keywords— Silica Fume, Polymers, Compressive Strength, Flexural Strength, Absorption.

INTRODUCTION

Concrete properties can be improved by using admixtures, silica fume can provide or give higher mechanical properties than ordinary concrete, and also some admixtures like polymers increase mechanical properties and decrease permeability of concrete and increase durability of concrete. silica fume powder has higher fineness than cement and react with some chemicals that liberate from hydration of cement and give less porosity concrete, and that lead to increase values of compressive, tensile and flexural strength of concrete and increase durability [1, 2]. Polymers like styrene butadiene rubber (SBR) give higher mechanical properties and improves durability for concrete and also increase ductility and impact strength of concrete [3]. this research aims to improve mechanical properties and decrease absorption for special type of concrete that having crushed waste glass as coarse aggregate to decrease the cost of concrete and also cleaner environment by using waste glass.

EXPERIMENTAL PROGRAM

Materials

The sulfate resistance cement used in all mixes, coarse aggregate used in this study with 16 mm maximum size, table 1 shows grading of coarse aggregate used in the study. The waste glass aggregate was crushed and replaced with 50% from ordinary coarse aggregate then taking the sieve analysis to confirm the specifications, fine aggregate grading shown in table 2. both sieve analysis of fine and coarse aggregate confirms Indian standards IS-383 [4]

Table 3 shows the ingredients for each one cubic meter of concrete.

Specimens and Testing

Cubic molds specimens with 100*100*100 mm were used to cast concrete for testing compressive, cylinders with 100*200 used for testing tensile strength (splitting test method) and beams with 100*100*400 mm for testing flexural strength of concrete, figure 1 shows some specimens before testing. the flexural test done by using third point loading, and the value of flexural strength obtained from equation 1 , all specimens tested after 28 days. Figure 2 shows the beam under testing for flexural test.

$$Fr = P*L / b*d^2 \quad \text{--(1)}$$

Tensile strength value obtained from equation 2

$$Ft = 2\,P / \pi *D*L \quad \text{--(2)}$$

Absorption test done by using cylinders, and dried in oven in 100 degrees for 24 hours, then taking the dry weight , then it cooled and submerged in water for 24 hours then taking the saturated weight , figure 3 shows cylindrical specimens in oven for absorption test .the %absorption value is obtained from equation 3 .

% ABS= [(Ws – Wd) / Wd] * 100 ------------------------------(3)

Where:

Ws = saturated weight of concrete

Wd = dry weight of concrete

ABS: Absorption of concrete

Figure 1: Some specimens before testing.

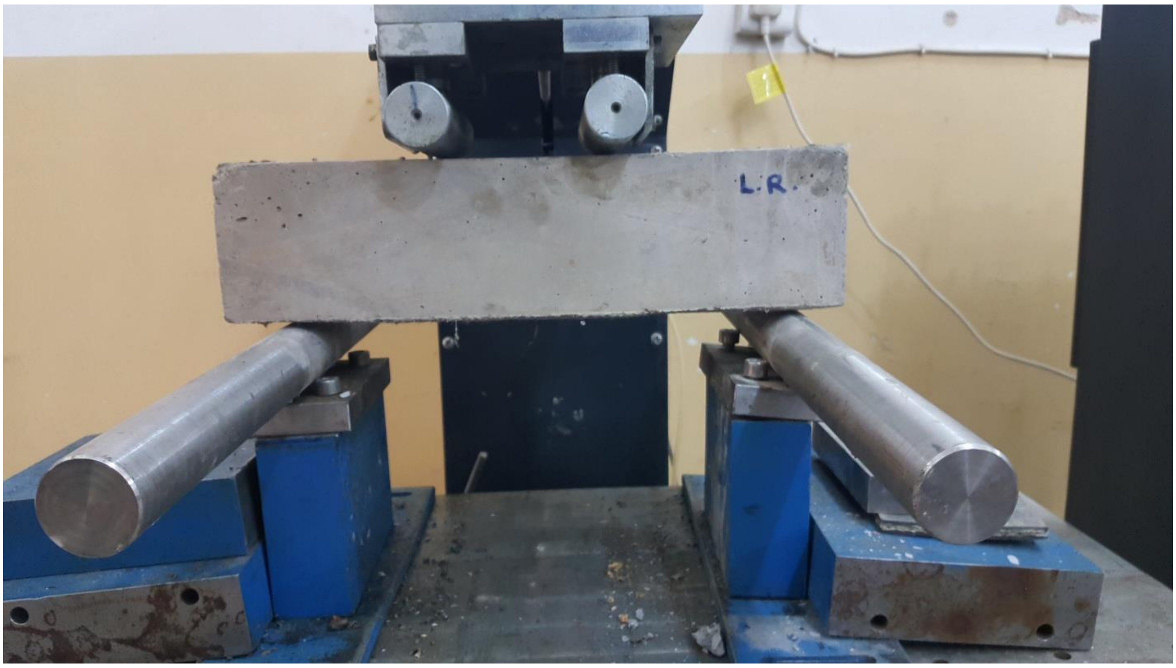

Figure 2: Concrete beam under tasting for flexural strength.

Figure 3: Drying specimens in oven for absorption test.

Table 1: Grading of coarse aggregate used in study.

Sieve size	**% Passing by weight**	**IS-383 Standards**
20	100	100
16	91.3	90 - 100
10	35.6	30 - 70
5	1.2	0 - 10

Table 2: Grading of fine aggregate used in study.

SIEVE Size	**% passing**	**IS-383 ,STANDARDS FOR ZONE 2**
10 mm	100	100
5 mm	95.2	90 100
2.36 mm	86.7	75 - 100
1.18 mm	78.8	55 -90
600 mic	58.1	35 -59
300 mic	27.0	8 -30
150 mic	8.1	0 -10

Table 3: Ingredients of concrete reference mix used in the study.

Ingredient	**cement**	**Sand**	**Coarse agg**	**water**	**Super plasticizer**
	500	740	970	202	0.8 liter for 100 kg cement

RESULTS AND DISCUSSION

Table 4 show the results of mechanical properties and absorption percentages for concrete not contains polymers ,the compressive strength increased when adding silica fume , the compressive strength increased from 40.23 MPa for reference mixes to 64.8 MPa when adding 15 % silica fume , tensile strength also increased from 2.88 to 5.2 MPa , and flexural strength increased from 3.8 to 10.5 MPa ,the main reason for this increment is the action of silica fume inside concrete , the silica fume is highly and quickly react with some hydrated particles of cement especially calcium hydroxide and forming additional gel particles that fill the pores and cavities inside concrete, and therefore gives additional strength to concrete [5 , 6]. Figures 4,5,6, and 7 show the relationship between compressive, tensile, flexural strength, and absorption with percentages of silica fume used in study. Absorption decreased highly when using silica fume, it decreased from 6% to 2.8 % and the reason attributed of the less porosity of concrete containing silica fume.

Table 5 shows the using both silica fume and 10% SBR polymer, it can be seen from table that compressive , tensile and flexural strengths increased more than using only silica fume, compressive strength increased from 40.23 to 69.2 MPa , tensile strength increased to 5.61 MPa and flexural strength increased to 12.3 MPa , and the reason for this case can be attributed to the formations of polymer films in side concrete [7] ,those polymer films can bond highly with external silica of aggregates and also bond with gel particles and that give another strength or additional strength to concrete [8], absorption also decrease more than concrete with silica only , the absorption here decrease to only 1.52 %. Figures 8, 9,10, and 11 show comparison between these two types of concrete for absorption and mechanical properties.

Table 4: Mechanical properties and absorption results of concrete for different ratios of silica fume (for mixes not containing SBR polymer).

Mix type	**Compressive strength**	**Tensile strength**	**Flexural strength**	**Absorption %**
Reference mix (with 50% crushed glass as coarse agg)	40.23	2.88	3.85	6.01
With 5% silica fume	48.92	4.26	5.34	4.50
With 10 % silica fume	63.73	5.04	9.46	3.27
With 15% silica fume	64.85	5.23	10.55	2.85

Table 5: Mechanical properties and absorption results of concrete for different ratios of silica fume (for mixes containing SBR polymer).

Mix type	**Compressive strength**	**Tensile strength**	**Flexural strength**	**Absorption %**
Reference mix (with 50% crushed glass as coarse agg)	40.23	2.88	3.85	6.01
With 5% silica fume+ polymer	50.19	4.92	6.13	3.80
With 10 % silica fume+ polymer	65.83	5.45	10.40	2.61
With 15% silica fume+ polymer	69.25	5.61	12.3	1.52

CONCLUSIONS

1- Silica fume give higher mechanical properties compared to ordinary mixes, compressive strength increased from 40.2 to 64.8 MPa by adding 15% silica fume, flexural and tensile strengths also increased by adding silica fume, and absorption decrease from about 6% to 2.8% and that is very significant effect that lead to reduce permeability and increase durability of concrete.

2- By using both SBR latex and silica fume, the mechanical properties of concrete increased highly or in higher values compared with silica-concrete, and absorption reduced to only 1.5%.

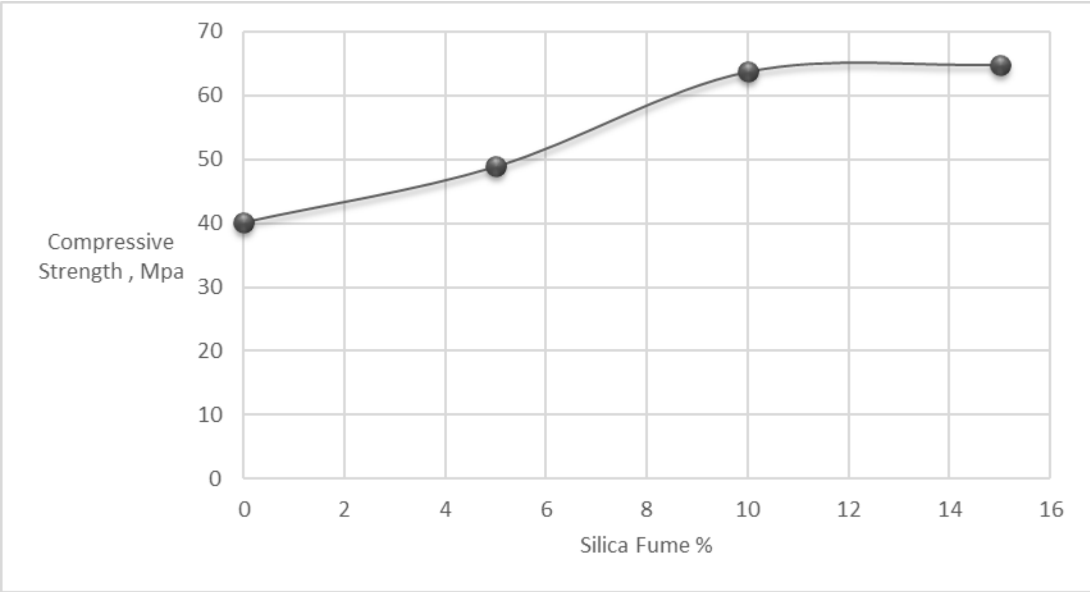

Figure 4: Relationship between compressive strength and percentages of silica fume, for silica fume concrete (without polymers)

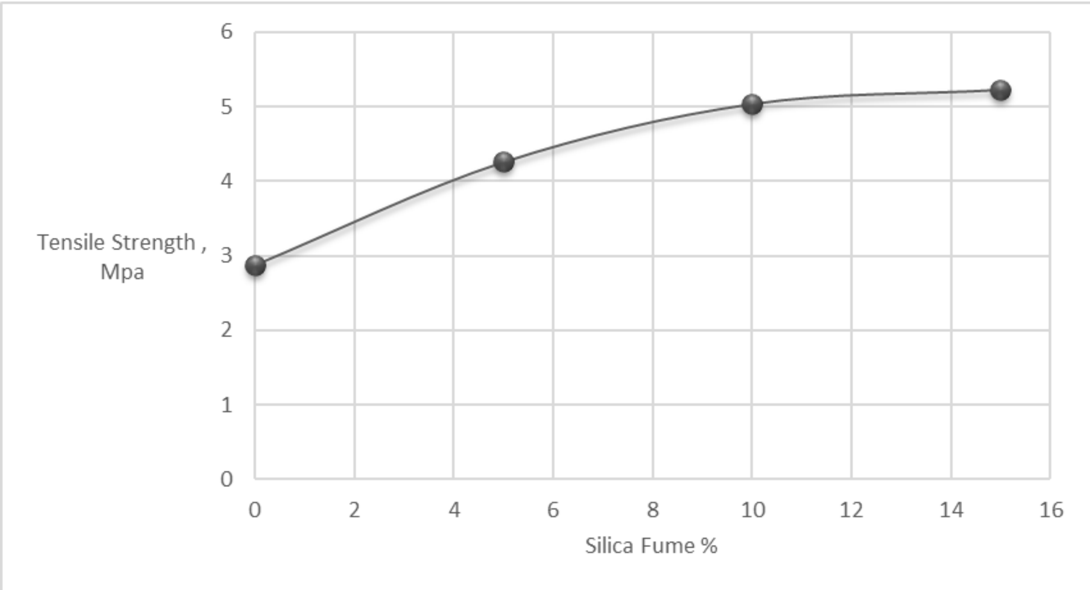

Figure 5: Relationship between tensile strength and percentages of silica fume, for silica fume concrete (without polymers)

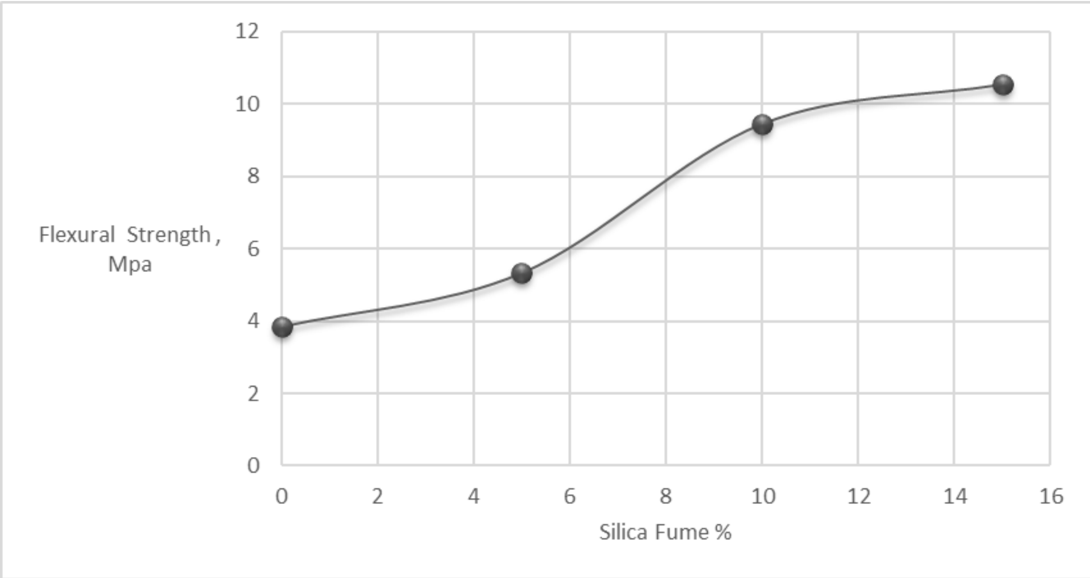

Figure 6: Relationship between flexural strength and percentages of silica fume, for silica fume concrete (without polymers)

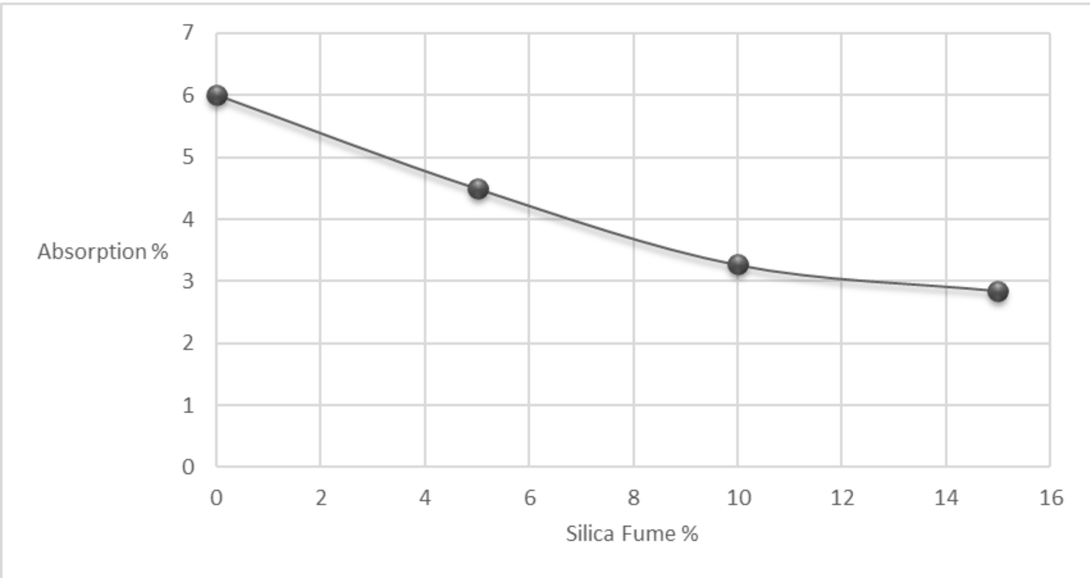

Figure 7. Relationship between absorption and percentages of silica fume, for silica fume concrete (without polymers)

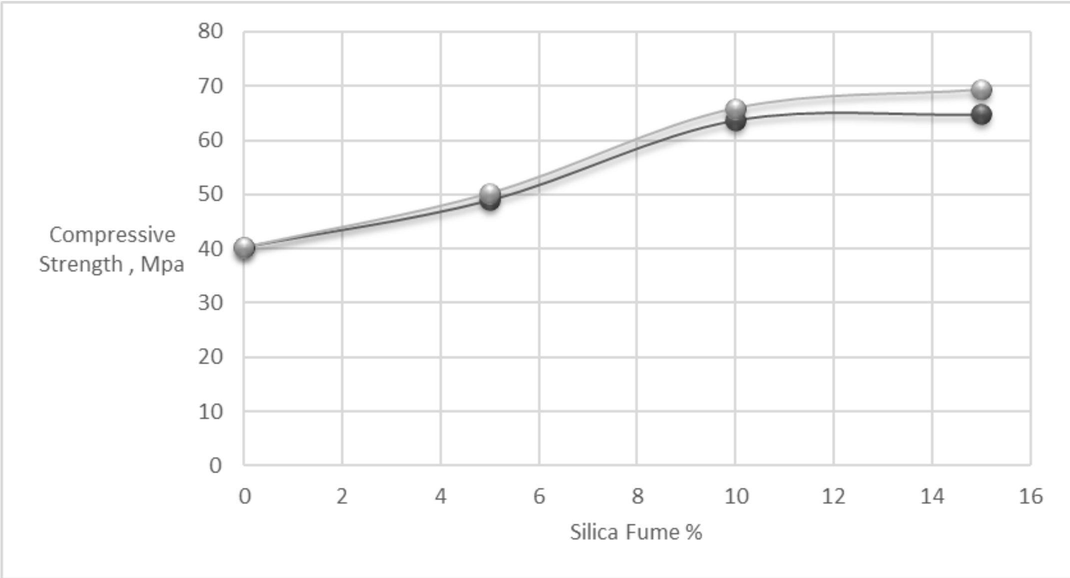

Figure 8: Comparison between silica-polymer concrete (above) and silica concrete for compressive strength test.

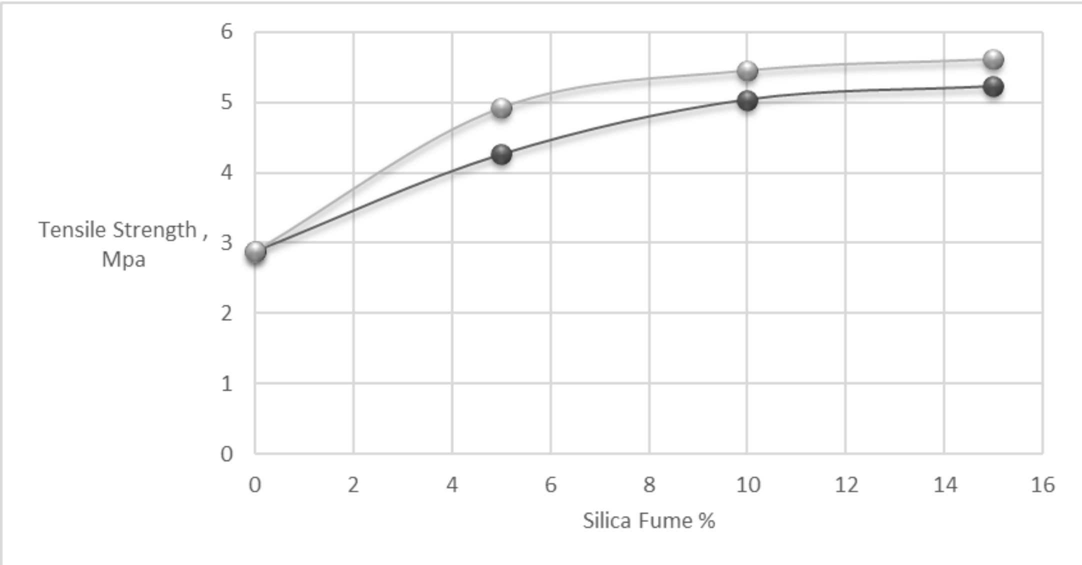

Figure 9: Comparison between silica-polymer concrete (above) and silica concrete for tensile strength test.

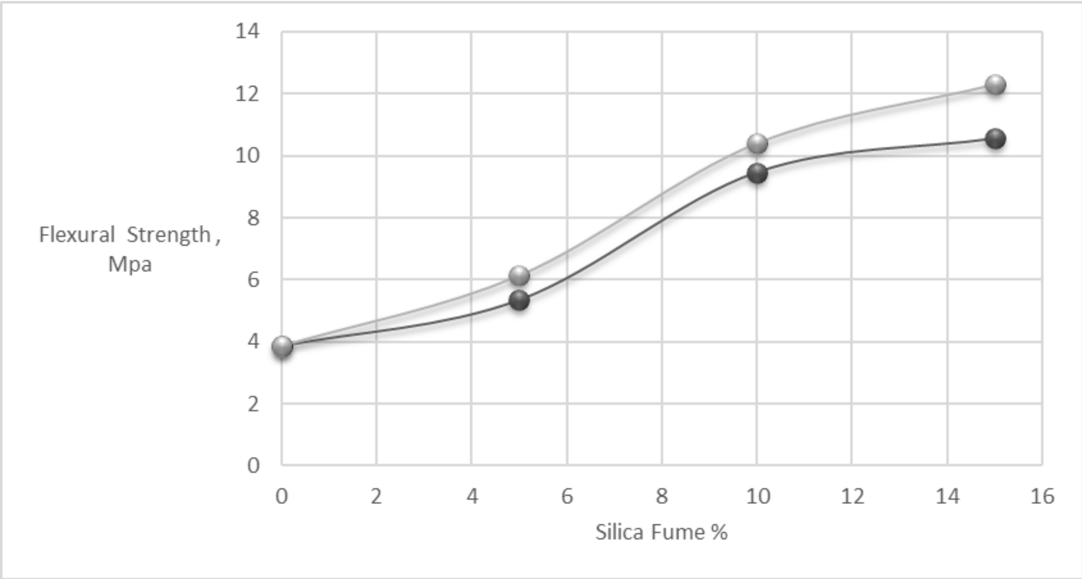

Figure 10: Comparison between silica-polymer concrete (above) and silica concrete for flexural strength test

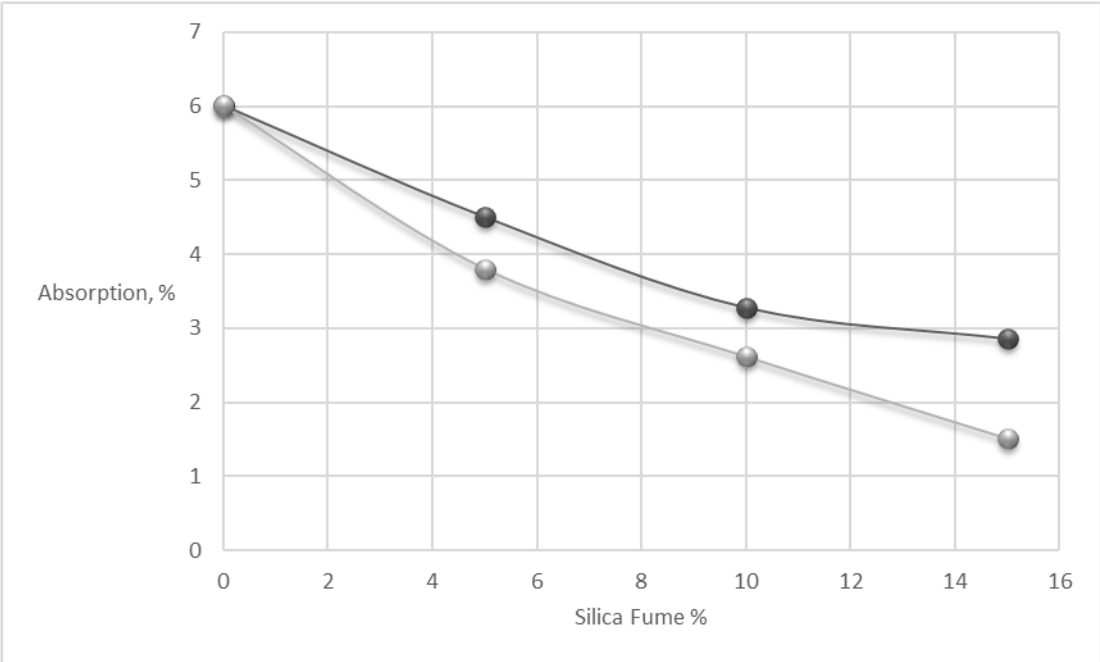

Figure 11: Comparison between silica-polymer concrete (red curve) and silica concrete (blue curve) for absorption test

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