# Experimental investigation of the effects of pozzolan and slag addition on mechanical properties of self-compacting cementitious composites

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**ABSTRACT:**

The use of concrete in industry is expanding. Self-compacting composite concrete is known as a cement composite with high performance and adhesion. This composite has a lot of psychological capabilities and efficiency, so that the use of this concrete, in addition to reducing construction time, also reduces costs. Self-compacting composites fit into the mold without the need for vibration and pass through the smallest seam. In this study, the effects of adding microsilica, fly ash and GGBFS pozzolan on the mechanical properties of self-compacting cement composite were investigated in 8 mixing designs. In making samples, 3 alternative cement additives at the rate of 10% were used in different mixing designs. In the compressive strength test, the sample with 10% microsilica increased the resistance by 5.4% more than the reference sample, which showed that the addition of microsilica increases the strength and water absorption in the samples. However, these pozzolans reduce the flow of self-compacting concrete. On the other hand, in the design of air ash mixtures, the resistance was reduced, but no significant changes were observed for slag. In total, other experiments such as tensile strength, flexural strength, water absorption, capillary, ultrasonic pulse velocity and impact resistance were performed on the mixing design.

**KEYWORDS**

Self-compacting cementitious composites, Micro silica fume, Fly ash, GGBFS, Mechanical properties

## 1. Introduction

Concrete is one of the most consumed building materials in the world. With the expansion of the use of concrete, properties such as durability, quality, density and optimization are of particular importance [1]. Concrete is one of the most important building materials that has many benefits such as high durability, low cost and supply of materials [2]. Composite concrete is a very fluid and homogeneous mixture that has solved many of the common concrete problems such as separation, water, water absorption, permeability, etc. [3]. Composite self-compacting was first introduced to achieve sustainable concrete structure in 1988, and initial studies of Ozawa concrete by Ozawa in 1989 and Okamura in 1993 were conducted at Tokyo University [4]. According to Bartus [5] the concrete is self -sufficient concrete that flows under its weight and fills and maintains its homogeneity without the need for any shaking. Concrete is a substance that is in high pressure and in weak and fragile stretching [6]. Research shows that the combination of Pozolani and cement by -products (or mineral additives in concrete) causes a significant increase in fresh and hardened modes [7]. GGBFS is a mineral mixed from the steel industry. This slag is used as a replacement of cement in concrete. The use of GGBFS reduces some concrete properties such as hydration heat, concrete permeability, and alkaline chloride reaction. As a result, it will have a huge impact on reinforced concrete function [8]. Well proven that mineral additives such as inflatable ash and slag may increase the efficiency, durability and long -term properties of concrete [9].

## 2. Methodology

### 2. 1. Specimens

In order to study the effects of adding fly ash, slag (GGBFS) and micro silica fume, 8 mix designs were developed in accordance with Table 1. First, aggregates and cementitious materials, along with dry additives, were placed into the mixer. Then, after mixing the dry materials, nearly 90% of the required water was added to the mixture. The remaining required water was gradually added to the mixture, along with the superplasticizer. After due mixing of materials in the mixing machine, the specimens were transferred into the molds. After 24 hours, the specimens were taken out of the molds. Finally, the developed specimens were placed into water for 28 days for appropriate curing.

### 2. 2. Tests procedure

J-Ring, L-box, U-box and V-funnel tests were performed to measure the performance of fresh concrete. The results of fresh concrete tests are in accordance with the [10] EFNARC standard. Compressive strength test of cementitious composites using 200 ton compression jack according to ASTM C39 standard for 100 * 100 * 100 mm cubic specimens, Brazilian tensile test (halving) according to ASTM C496 standard on zinc. Cylindrical specimens measuring 100 * 200 mm have flexural strength based on the three-point load test of ASTM C293-79. For this purpose, in accordance with the mentioned standard, three-point bending test was performed on bending specimens. Bending specimens had a characteristic of 60 * 80 * 320 mm. Water absorption test according to ASTM C642 standard on 10 * 50 mm cylindrical samples, capillary test according to ASTM C1585 standard, ultrasonic sample test according to ASTM C597 standard on cube samples with 100 * 100 * 100 mm method, also your impact test according to regulations ACI 544 was performed. In order to perform the drop test, disk samples of 65 * 150 mm were made.

## 3. Results and Discussion

The use of microsilica (due to water absorption) reduced the psychological of cement composite. However, wind ash and slag had little effect on cement composite psychological changes. This property was quite evident in the results of water and capillary absorption tests.

**Table 1.** Mix proportions.

| NO. | Specimens Name | Cement (Kg) | Fine aggregate (Kg) | GGBFS G% | Fly Ash FA% | Micro Silica MS% | SP (Kg) |
|---|---|---|---|---|---|---|---|
| 1 | G0FA0MS0 (Ref) | 1200 | 1200 | 0 | 0 | 0 | 3.6 |
| 2 | G0FA0MS10 | 1080 | 1200 | 0 | 0 | 10 | 4.8 |
| 3 | G0FA10MS0 | 1080 | 1200 | 0 | 10 | 0 | 3.6 |
| 4 | G10FA0MS0 | 1080 | 1200 | 10 | 0 | 0 | 3.6 |
| 5 | G0FA10MS10 | 960 | 1200 | 0 | 10 | 10 | 3.6 |
| 6 | G10FA0MS10 | 960 | 1200 | 10 | 0 | 10 | 4.8 |
| 7 | G10FA10MS0 | 960 | 1200 | 10 | 10 | 0 | 3.6 |
| 8 | G10FA10MS10 | 840 | 1200 | 10 | 10 | 10 | 4.8 |

Microsilis had a positive effect on increased compressive and bending resistance, but wind fly ash and slag had no effect on compressive strength and reduced this resistance. In the unarmed bending beams, as soon as the first crack was created, the sample was divided into half.

The use of two pozzolans of microsilica and fly ash as well as slag had no effect on tensile strength and even reduced tensile strength. In other words, it can be concluded that in the design of air ash mixtures, the resistance generally decreases due to the chemical reaction of this material with cement and other cement additives (see Fig. 1).

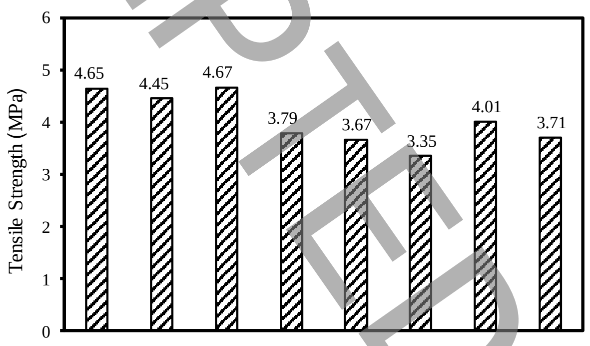


**Fig. 1.** Graph of the flexural strength of beams (MPa).

## 4. Conclusion

The use of microsilica in mixing design increased the mechanical properties of self -compact concrete. The use of inflatable ash reduced this feature so that, in combination with microsilica, it reduced the positive effect of this cement additive. Using GGBFS did not have a great impact on increasing and reducing experiments

## References


[1] M. Soleymani Ashtiani, Allan N. Scott, Rajesh P. Dhakal., Mechanical and fresh properties of high-strength self-compacting concrete containing class C fly ash, Construction and Building Materials, 47 (2013) 1217-1224.

[2] N. Banthia, M. Sappakittipakom., Toughness enhancement in steel fiber reinforced concrete through fiber hybridization, Cement and Concrete Research, 37 (2007) 1366-1372.

[3] Wild S, Sabir BB, Khatib JM., Factors influencing strength development of concrete containing silica fume, Cement and Concrete Research, 25 (1995) 1567-1580.

[4] Ozawa K, Maekawa K, Okamura H., Self-Compacting high performance concrete, Structural Engineering International, 6 (1996) 269-270.

[5] Bartos P.J.M, Gibbs J.C, Zhu W., Uniformity of in situ properties of Self-Compacting Concrete in full scale structural elements, Cement and Concrete Composites, 23 (2001) 57-64.

[6] A. Terzić, L. Pezo, V. Mitić, Z. Radojević., Artificial fly ash based aggregates properties influence on lightweight concrete performances, Ceramics International, 41 (2015) 2714–2726.

[7] Y. Jeong, H. Park, Y. Jun, J. H. Jeong, J. E. Oh., Microstructural verification of the strength performance of ternary blended cement systems with high volumes of fly ash and GGBFS, Construction and Building Materials, 95 (2015) 96–107.

[8] J. Musdif Their, M. Özakça., Developing geopolymer concrete by using cold-bonded fly ash aggregate, nano-silica, and steel fiber, Construction and Building Materials, 180 (2018) 12–22.

[9] Oh J.E., Jun Y., Jeong Y., Monteiro P.J.M., The importance of the network-modifying element content in fly ash as a simple measure to predict its strength potential for alkali-activation, Cement & Concrete Composites, 57 (2014) 44-54.

[10] Carino N.J., Lew H.S., Re-examination of the relation between splitting tensile and compressive strength of normal weight concrete, ACI Materials Journal. 79 (1982) 214–219.