Erudite Journal of Engineering Technology and Management Sciences

Vol. 3, No. 1, March, 2023, pp. 01-04

Journal homepage: http://www.ejetms.com

Investigation on Mechanical Properties of Silica Fume Blended High Strength Concrete

J Guru Jawahar[1], B.Srinadh[2], B.Prudvi Raj[3], U.Shireesha[4], C.Vijay Kumar[5], P.Narasimha[6]

[1] Professor, Department of Civil Engineering, Annamacharya Institute of Technology and Sciences, Autonomous, Tirupati, India-517520

[2-6] B.Tech Student, Department of Civil Engineering, Annamacharya Institute of Technology and Sciences, Autonomous, Tirupati, India-517520

Corresponding Author Email: srinadhbhogyam@gmail.com

Received: 18 January 2023

Accepted: 16 March 2023

Keywords:
Mechanical Properties, compressive Strength, Spliting strength

ABSTRACT

The investigation on the mechanical properties of silica fume blended high-strength concrete aims to study the effect of adding silica fume as a partial replacement of cement on the M60, M70 and M80 grade of high strength concrete. In this study, silica fume was kept at 15% by weight of cement, and the resulting concrete was tested for compressive strength and splitting tensile strength. The results show that the 15% replacement of silica fume improved the mechanical properties of concrete significantly. It is observed that as curing period increases, the compressive strength and splitting tensile strength values were increased. It is concluded that the optimum proportion of silica fume significantly contributed to the strength of high strength concrete.

1. INTRODUCTION

High-strength concrete (HSC) is a type of concrete that exhibits superior strength, durability, and stiffness compared to conventional concrete [1]. It is commonly used in high-rise buildings, bridges, and other infrastructure projects where structural integrity is critical. Silica fume is a byproduct of the production of silicon and ferrosilicon alloys and is a highly reactive pozzolan that can enhance the mechanical properties of concrete when used as a partial replacement of cement [2].

The combination of silica fume with HSC can result in a concrete mix with significantly improved mechanical properties, including higher compressive and tensile strength, improved durability, and reduced permeability [3]. This blend is increasingly used in critical structures like nuclear power plants, tunnels, and offshore structures [4].

This investigation aims to study the mechanical properties of silica fume blended high strength concrete. The study will evaluate the compressive and tensile strength, flexural strength, modulus of elasticity, and fracture toughness of the concrete mix. Additionally, the investigation will analyze the microstructure of the blend, including the pore size distribution, porosity, and interfacial transition zone [5].

The results of this study are expected to provide insight into the potential benefits of using silica fume in high strength concrete mixes and offer valuable information to the construction industry. The investigation will also help engineers and contractors design and construct more durable and reliable infrastructure projects with improved mechanical properties.

2. OBJECTIVE

The objective of the investigation is to study the mechanical properties of high-strength concrete blended with silica fume, a byproduct of the production of silicon and ferrosilicon alloys. The study aims to analyze the effect of 15% replacement level of silica fume on the mechanical properties of the concrete, such as compressive strength and splitting tensile strength. The investigation also seeks to identify the optimal amount of silica fume that can be added to the concrete mix to enhance its strength while ensuring its durability and workability. The findings of this investigation can provide valuable insights into the use of silica fume as a sustainable and cost-effective alternative to traditional concrete additives for high-strength concrete applications.

3. LITERATURE SUMMARY

High-strength concrete (HSC) is a type of concrete that is designed to withstand high compressive stresses, typically exceeding 50 MPa. Silica fume (SF) is a byproduct of the production of silicon and ferrosilicon alloys, which has been found to enhance the mechanical properties of concrete when added to the mix. This literature review summarizes several studies that investigate the mechanical properties of silica fume blended high-strength concrete.

Many studies have demonstrated that adding SF to the HSC mix increases its compressive strength significantly. Other studies by Ghrici et al. (2007) and Al-Negheimish et al. (2013) also found that SF improved the compressive strength of HSC, with the optimum SF content ranging from 5% to 10%.

In addition to compressive strength, SF has also been found to improve the flexural and splitting tensile strength of HSC. A study by Khayat et al. (1992) showed that HSC blended with

5% SF had a flexural strength of 10.2 MPa, which was 21% higher than that of the control mix. Another study by Ahmari and Zhang (2012) demonstrated that SF improved the splitting tensile strength of HSC, with the optimum SF content ranging from 5% to 8%.

However, it is important to note that SF can also affect the workability and durability of HSC. Several studies have reported that high SF content can lead to a reduction in workability and increase in the rate of chloride ion penetration, which can affect the long-term durability of the concrete. Therefore, it is essential to determine the optimal SF content that can enhance the mechanical properties of HSC while ensuring its workability and durability.

Overall, the literature review suggests that SF can be an effective additive to enhance the mechanical properties of HSC. However, further research is needed to investigate the optimal SF content, as well as its long-term performance and sustainability aspects.

4. EXPERIMENTAL INVESTIGATION

4.1 Compression Test

The compression test is a widely used method for measuring the compressive strength of concrete. In this test, a cylindrical or cubical concrete specimen is placed between two steel bearing plates or blocks, and a compressive load is applied axially along the length of the specimen until it fractures. The load is applied at a constant rate until the specimen fails, which is typically indicated by a sudden drop in the load applied.

To perform the compression test, the concrete specimen is placed horizontally between the two steel bearing plates or blocks, which are aligned to ensure that the load is applied axially along the length of the specimen. The load is then applied at a constant rate until the specimen fails, and the maximum load applied to the specimen is recorded. The compressive strength of the specimen is calculated by using the following formula:

$$\text{Compressive strength} = P/A$$

Where P is the maximum load applied to the specimen, and A is the cross-sectional area of the specimen.

Figure 1. Compression test setup

The compression test is widely used to measure the compressive strength of concrete in various applications, such as construction, infrastructure, and material testing. It is commonly used to evaluate the quality and strength of concrete, particularly for high- strength concrete and concrete blended with additives such as silica fume. The results of the compression test can provide information about the suitability of the concrete for its intended application, as well as the durability and long- term performance of the concrete.

4.2 Split Tensile Test

The splitting tensile strength test is a common method used to measure the tensile strength of concrete specimens. In this test, a cylindrical or prismatic concrete specimen is loaded axially along its length until it fractures. The load is applied through two steel bearing plates or blocks that are placed at the ends of the specimen.

To perform the splitting tensile strength test, the concrete specimen is placed horizontally between the two steel bearing plates. The load is applied at a constant rate until the specimen fractures. During the test, the tensile stress is distributed along a plane perpendicular to the applied load, which causes the specimen to split into two halves. The maximum load applied to the specimen is recorded, and the splitting tensile strength is calculated using the following formula:

$$\text{Splitting tensile strength} = 2P/\pi DL$$

Figure 2. Split Tensile test setup

Where P is the maximum load applied to the specimen, D is the diameter of the cylindrical specimen or the shorter side of the prismatic specimen, and L is the length of the specimen.

The splitting tensile strength test is commonly used to evaluate the tensile strength of concrete, particularly for high-strength concrete and concrete blended with additives such as silica fume. It can also provide information about the quality and workability of the concrete mix, as well its ability to resist cracking and deformation under tensile stress.

5. TEST RESULTS AND ANALYSIS

5.1 Compressive Strength Test

In general, the calculation of the compressive strength test is performed on a sample with cube sizes of 10 cm x 10 cm x

10 cm. In this experiment we use a nominal size of aggregates of 10 mm. This test is performed to calculate the compressive strength of the hardened concrete. This is one of the destructive tests of hardened concrete. We test cubes after curing with a time interval of 7 days, 14 days and 28 days. The compressive strength test refers to the concrete characteristic properties.

Table 1. Compressive strength values

Grade of concrete used	Duration for testing		
	7 days	14days	28 days
M60	47.75	63.42	71.26
M70	53.94	71.37	79.32
M80	59.89	80.09	88.89

From the above results, it is seen that concrete of grade M60 attained the minimum compressive strength values when compared to the other two mixes after 7 days, 14 days and 28 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of 53.94 MPa and 59.89 MPa when compared to mixes of M60 (47.75 MPa) after 7 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of 71.37 MPa and 80.09 MPa when compared to mixes of M60 (63.42 MPa) after 14 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of 79.32 MPa and 88.89 MPa when compared to mixes of M60 (71.26 MPa) after 28 days of curing.

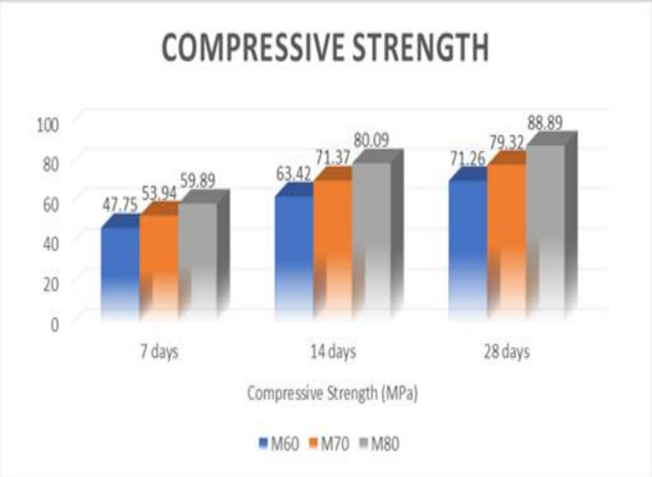

Figure 3. Compressive strength values

Graph showing compressive strength test results versus Number of days for different grade of concrete. From the results obtained, it is revealed that the increase of compressive strength took place at an age of 28 days for all the mixes. It is clearly seen that for the mix M80, the compressive strength at all the ages is more compared to the other mixes M60 and M70.

5.2 Split Tensile Test

From the above results, it seems that concrete of grade M60 attained the minimum compressive strength values when compared to the other two mixes after 7 days, 14 days and 28 days of curing. The mixes of M70 and M80 have attained the maximum Split tensile values of 2.87MPa and 3.28MPa when compared to mixes of M60 (2.07MPa) after 7 days of curing. The mixes of M70 and M80 have attained the maximum Split tensile values of 3.43MPa and 4.25MPa when compared to mixes of M60 (2.75MPa) after 14 days of curing. The mixes of M70 and M80 have attained the maximum compressive strength values of 4.21MPa and 4.37MPa when compared to mixes of M60 (3.59MPa) after 28 days of curing.

Table 2. Split tensile strength values

Grade of concrete used	Duration for testing		
	7 days	14days	28 days
M60	2.07	2.75	3.59
M70	2.87	3.43	4.21
M80	3.28	4.25	4.37

6. CONCLUSION

- The preliminary investigation, it is difficult to provide a conclusive statement on the mechanical properties of silica fume blended with high strength concrete.
- The 15% replacement of silica fume improved the mechanical properties of concrete significantly.
- It is observed that as curing period increases, the compressive strength and splitting tensile strength values were increased.
- It is concluded that the optimum proportion of silica fume significantly contributed to the strength of high strength concrete.

REFERENCES

[1] Mazloom, M., Ramezanianpour, A. A., & Brooks, J. J. (2004). Effect of silica fume on mechanical properties of high-strength concrete. *Cement and concrete composites*, 26(4), 347-357.

[2] Shanmugapriya, T., & Uma, R. N. (2013). Experimental investigation on silica fume as partial replacement of cement in high performance concrete. *The International Journal of Engineering and Science*, 2(5), 40-45.

[3] Imam, A., Kumar, V., & Srivastava, V. (2018). Review study towards effect of Silica Fume on the fresh and hardened properties of concrete. *Advances in concrete construction*, 6(2), 145.

[4] Almusallam, A. A., Beshr, H., Maslehuddin, M., & Al-Amoudi, O. S. (2004). Effect of silica fume on the mechanical properties of low quality coarse aggregate concrete. *Cement and Concrete Composites*, 26(7), 891-900.

[5] Jianyong, L., & Pei, T. (1997). Effect of slag and silica fume on mechanical properties of high strength concrete. *Cement and Concrete Research*, 27(6), 833-837.