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# Experimental Testing of SSC based on Slump Flow Test, V-funnel test, and L-box test

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## Abstract

Self-consolidating concrete (SCC) can flow and compact itself under its own weight, even in areas with closely spaced reinforcement. This research examines the characteristics of SCC using materials such as fine and coarse aggregates, cement, superplasticizer, marble powder, and silica fume. Five beam specimens were tested, each with varying proportions of cement, silica fume, and marble powder. The experimental procedures included the slump flow test, V-funnel test, and L-box test. The results showed that the average compressive strength was approximately 31.33 MPa at 5 days, increasing to 42.07 MPa at 30 days. These findings suggest that self-consolidating concrete exhibits reliable performance.

**Keywords:** Self-Consolidating Concrete, Durability, Cement, Concrete.

## INTRODUCTION

With the increasing use of concrete in modern construction, new types of concrete with specialized properties have been developed to meet diverse application needs. One such advancement is self-consolidating concrete (SCC), which does not require external compaction or vibration during placement. SCC can flow and fully compact itself under its own weight, even in areas with dense reinforcement. It matches the strength of traditional vibrated concrete while retaining the core characteristics of conventional concrete. Initially introduced in Europe during the 1970s, an improved version of SCC was later developed in Japan in the 1980s. Today, it is extensively used across industrial and construction sectors.

SCC offers several advantages over conventional concrete, including faster placement, shorter construction times, and the ability to flow easily through congested areas. Structures made with SCC exhibit enhanced durability, superior surface finishes, consistent concrete strength, reduced void formation, and better homogeneity. Its low water-to-cement ratio contributes to higher strength and faster demolding. Other key benefits include improved workplace safety, lower noise levels, elimination of vibration, increased design flexibility, thinner sections, easier placement, reduced labor needs, and quicker project completion. These attributes make SCC one of the most significant innovations in concrete technology. Furthermore, the development of advanced plasticizers has enhanced SCC's performance, making it a preferred choice for both precast and on-site concrete applications.

### Key Features of Self-Consolidating Concrete

Achieving higher workability in concrete requires maintaining adequate spacing between aggregates to reduce internal friction. Properly spaced aggregates are enveloped by cement paste, allowing for efficient compaction and the removal of surplus paste. This process results in a layered structure, where the upper portion consists mainly of cement paste, while the lower part contains densely packed aggregates with enough cement paste to fill any gaps. The paste filling these gaps is known as "compact paste," while the paste coating the aggregates is referred to as "excess paste." The presence of excess paste enhances the concrete's ability to flow smoothly and promotes uniform distribution throughout the mixture.

## REVIEW OF PAST LITERATURE

Numerous studies have examined various aspects of self-consolidating concrete (SCC) using experimental and test-based methodologies. For instance, Felekoglu (2008) investigated SCC production and discovered that maintaining consistency required modifying the physical properties of the sand. The research indicated that using CLS sand increased the need for admixtures while reducing the concrete's strength. Additionally, a higher admixture content extended the setting time for SCC containing CLS sand. The study offered guidelines for selecting suitable sand types and quantities.

Similarly, Siddique (2008) explored SCC as a fluid mixture capable of being placed in areas with dense reinforcement without the need for external vibration. The research highlighted the importance of balancing stability and deformability for effective SCC performance. It also demonstrated that SCC's compactability depends on the material composition and mix proportions. The study proposed an experimental approach for designing SCC mixes and used tests such as the L-box, V-funnel, and J-ring to evaluate the concrete's workability and acceptance characteristics.

Okamura and Ozawa (1995) investigated self-consolidating concrete (SCC) and discovered that aggregate movement could be improved using transparent polymer leads. Their research demonstrated that adjusting variables such as coarse aggregate content, superplasticizer dosage, and the water-to-cement (w/c) ratio could enhance the concrete's filling capacity and shear resistance. They proposed a method for optimizing these factors and observed that the ratio of slump flow index to funnel flow index remains nearly constant for a given superplasticizer-to-cement ratio when the water-to-cement ratio is adjusted.

In a separate study, Okamura and Ozawa (1995) evaluated the fillability of SCC through tests including the U-box, L-box, funnel flow, and slump flow. The findings indicated that the self-compatibility of SCC is primarily influenced by the w/c ratio and should be determined based on the specific strength requirements.

Collepardi (1980) conducted experiments on self-consolidating concrete (SCC) and recognized it as a significant advancement in cement-based materials. The research emphasized the importance of carefully selecting key components—such as silica fume, ground limestone, fly ash, cement, and superplasticizers—based on their ability to prevent segregation and enhance sustainability.

## MATERIAL AND METHODS

Table 1

*Fine Aggregate*

| S. No | Properties | Values |
|---|---|---|
| 1 | Bulk Density | 2.2 |
| 2 | Fineness Modulus | 2.3 |
| 3 | Specific Gravity | 2.5 |

In this study, clean river sand is utilized as the fine aggregate. It is sieved through a 6.25 mm sieve to eliminate larger particles. Particles smaller than 0.095 mm are categorized as fine particles, which contribute to the powder content in the concrete mixture.

### Coarse Aggregate

Table 2

*Coarse Aggregate*

| S. No | Properties | Values |
|---|---|---|
| 1 | Bulk Density | 759 |
| 2 | Fineness Modulus | 2.57 |
| 3 | Specific Gravity | 2.1 |

In this study, crushed stone aggregate is used as the coarse aggregate, with particles passing through a 10 mm sieve. While aggregates typically constitute approximately 80% of the total volume in conventional concrete, they make up only about 35% of the total volume in self-consolidating concrete.

Table 3

*Cement*

| S. No | Properties | Values |
|---|---|---|
| 1 | Consistency | 39% |
| 2 | Specific Gravity | 3.15 |
| 3 | Initial Setting time | 35 min |
| 4 | Final Setting Time Test | 425 min |

Cement exhibits both cohesive and adhesive properties, enabling it to bind material fragments into a solid mass. It is regarded as one of the most essential components of concrete. Various types of cement are available, each designed for specific applications and characteristics. This study utilizes Portland cement.

### Superplasticizer

Superplasticizer is a crucial component in self-consolidating concrete to achieve the desired workability. This study uses Conplast SP440, a chloride-free superplasticizer based on sulphonated naphthalene polymers. It is mixed directly with water and aids in producing fine particles within the concrete mix. These fine particles enhance the efficiency of the water content, leading to improved concrete strength.

### Marble Powder

Marble natural stones produce a considerable amount of dust, which contributes to pollution in urban environments. Utilizing marble powder helps mitigate this dust, offering environmental benefits. In this study, the marble powder used had a specific gravity of approximately 1.963.

### Silica Fume

Table 4

*Chemical Composition of Silica Fume*

| S. No | Constituents | Quantity (%) |
|---|---|---|
| 1 | LOI | 4.25 |
| 2 | CAO | 2.1 |
| 3 | $FE_2O_3$ | 1.87 |
| 4 | $Ai_2 O_3$ | 0.39 |
| 5 | $SiO_2$ | 88.95 |

Silica fume improves the chemical properties of concrete by enhancing durability, strengthening the microstructure through its filler effect, and minimizing bleeding and segregation. It also promotes higher early strength development. In this study, the silica fume used had a specific gravity of 2.45.

### Specimen Description

Five beam specimens were utilized in the current study. The details of each specimen are provided in the table below.

Table 5

*Specimen Description*

| Specimen | Description |
|---|---|
| SP1 | Control Specimen |
| SP2 | 80% of cement, 12% of silica fume, 18% of marble powder |
| SP3 | 80% of cement, 12% of silica fume, 18% of marble powder |
| SP4 | 80% of cement, 12% of silica fume, 18% of marble powder |
| SP5 | 80% of cement, 12% of silica fume, 18% of marble powder |

The Proportion Mix of self-consolidating concrete is as follows.

Table 6

*Proportion Mix of Self-Consolidating Concrete*

| S. No | Materials | Quantity ($Kg/m^3$) |
|---|---|---|
| 1 | Super Plasticizer | 1.75% of powder |
| 2 | Water | 212 |
| 3 | Coarse Aggregate | 713 |
| 4 | Fine Aggregate | 919 |
| 5 | Cement | 325 |

### Tests for Fresh Properties of self-Consolidating Concrete

The slump flow test was the first assessment conducted in this study. It is commonly used to evaluate the horizontal flow and flow rate of self-consolidating concrete without obstructions. Initially, this test was developed to measure the flow characteristics of underwater concrete.

A higher slump flow value indicates that self-consolidating concrete (SCC) can fill formwork under its own weight. According to EFNARC guidelines, SCC should achieve a minimum slump flow of 650 mm. Although no universal tolerance limits exist, a variation of ±50 mm is generally considered acceptable. Another key parameter is the T500 time, which measures the time taken for the concrete to spread to a 500 mm diameter. A shorter T500 time indicates greater flowability, while a longer time suggests reduced flowability. Minor segregation may be visible as coarse aggregates collecting at the edges of the concrete pool. However, the absence of visible segregation does not guarantee that segregation has not occurred, as it may develop over time.

The V-funnel test evaluates the filling ability of concrete with a maximum aggregate size of 20 mm. Originally developed by Ozawa, this test involves filling a V-shaped funnel with concrete and measuring the time it takes to flow through the outlet. To check for segregation, the funnel can be refilled and left undisturbed for 5 minutes. An increase in flow time indicates the presence of segregation.

The flow time of concrete is used to evaluate its ease of movement, with shorter flow times indicating better flowability. According to EFNARC guidelines, self-consolidating concrete (SCC) should have a flow time of approximately 10 seconds. Longer flow times suggest a higher likelihood of blockage, especially due to the funnel's inverted cone shape, which may restrict flow. If the concrete is allowed to settle for 5 minutes, segregation can be detected by an increase in flow time and a less continuous flow.

The L-box test assesses the flowability of SCC and its ability to pass through reinforcement without obstruction. The apparatus consists of an L-shaped rectangular box with horizontal and vertical sections separated by a movable gate. Reinforcement bars are placed in the vertical section, and concrete is poured to evaluate how effectively it flows through and around the obstacles.

In the L-box test, concrete is poured into the vertical section, and the gate is lifted to allow it to flow into the horizontal section. The flow is stopped once the concrete reaches its maximum spread, and the height of the concrete in the horizontal section is measured. This height is then compared to the height of the remaining concrete in the vertical section, expressed as a ratio ($H_2/H_1$). This ratio indicates the concrete's passing ability, with a higher value suggesting better flow through reinforcement.

The slope of the concrete at rest reflects how much the reinforcement bars restrict the flow. Different reinforcement bar diameters and spacings can be used to simulate real-world conditions, allowing the assessment of SCC under varying levels of testing severity. Visual inspection helps identify any blockage of coarse aggregates behind the bars, providing further insight into potential flowability issues.

**Requirements of Self-Consolidate Cement**

The essential properties of self-consolidating concrete (SCC) are mainly evaluated in its fresh state. An effective mix design allows SCC to flow under its own weight without external vibration, enabling it to pass easily through densely reinforced areas. For concrete to qualify as self-consolidating, it must satisfy two fundamental criteria: filling ability and compressive strength.

Filling ability refers to the capacity of concrete to flow effortlessly into all areas of the formwork under its own weight, without the need for external vibration or energy, and without leaving voids. It also assesses the speed at which the concrete flows while maintaining its stability, ensuring the formwork is fully and uniformly filled

Compressive strength is measured by conducting a compression test on concrete cubes following standard guidelines. In this study, the concrete cube specimens were tested using a compression testing machine with a capacity of 2200 kN. The crushing strength is determined by applying a compressive load at a rate of 150 kN/min until the specimen reaches failure.

Table 7
*Results*

| S. No | Types of Sample | 5 Days compressive Strength (N/mm$^2$) | 30 Days compressive Strength (N/mm$^2$) |
|---|---|---|---|
| 1 | SP1 | 32.35 | 40.55 |
| 2 | SP2 | 33.55 | 44.23 |
| 3 | SP3 | 30.52 | 45.65 |
| 4 | SP4 | 29.68 | 40.25 |
| 5 | SP5 | 30.58 | 39.67 |
|  | Average | 31.336 | 42.07 |

The results show that the 5-day compressive strength of the specimens ranged from 29.68 MPa to 33.55 MPa, with an average of 31.33 MPa. For the 30-day compressive strength, the values ranged from 39.67 MPa to 45.65 MPa, with an average of 42.07 MPa.

## CONCLUSION

An experiment was conducted to evaluate self-consolidating concrete using different ratios of silica fume and marble powder, focusing on its flow and strength characteristics. The results from the slump flow test, V-funnel test, and L-box test revealed that increasing the proportion of silica fume led to higher compressive strength. Overall, the findings confirm that self-consolidating concrete meets performance expectations and exhibits satisfactory properties.

## References

Alam, F., Shubham, K., Kumar, S., & Srivastava, A. K. L. (2024). Enhancing high-strength self-compacting concrete properties through nano-silica incorporation and elevated temperature exposure. *Materials Science and Engineering: A*, *876*, 144-153. https://doi.org/10.1007/s41024-024-00386-7

Bamonte, P., & Gambarova, P. G. (2012). A study on the mechanical properties of self-compacting concrete at high temperature and after cooling. *Materials and Structures*, *45*(6), 1375-1387. https://doi.org/10.1617/s11527-012-9839-9

Choi, H., & Kim, Y. (2021). Effect of elevated temperature on mechanical properties of high strength self-compacting concrete. *International Journal of Engineering Research and Technology*, *10*(7), 345-351. https://www.academia.edu/44065135/IJERT_Effect_Of_Elevated_Temperature_On_Mechanical_Properties_Of_High_Strength_Self_Compacting_Concrete

Choi, H., & Kim, Y. (2021). Effect of elevated temperature on mechanical properties of high strength self-compacting concrete. *International Journal of Engineering Research and Technology*, *10*(7), 345-351. https://www.ijert.org/research/effect-of-elevated-temperature-on-mechanical-properties-of-high-strength-self-compacting-concrete-IJERTV10IS0782

De Schutter, G. (2005). Guidelines for testing fresh self-compacting concrete. *European Research Project*.

Efnarc. (2002). Specification and guidelines for self-consolidating concrete.

Fattah, A., & Ali, M. (2023). Stress-strain behavior of normal compacting and self-compacting concrete under elevated temperatures. *Journal of Structural Engineering*, *5*(1), 63-70. https://www.emerald.com/insight/content/doi/10.1260/2040-2317.5.1.63/full/html

Fattah, A., & Ali, M. (2023). Stress-strain behavior of normal compacting and self-compacting concrete under elevated temperatures. *Journal of Structural Engineering*, *5*(1), 63-70. https://doi.org/10.1260/2040-2317.5.1.63

Hertz, K. D. (1992). Danish investigations on silica fume concretes at elevated temperatures. *Materials Journal*, *89*(4), 345-347.

Khoury, G. A. (1992). Compressive strength of concrete at high temperatures: a reassessment. *Magazine of Concrete Research*, *44*(161), 291-309.

Nguyen, P. T., & Lee, K. H. (2023). Behavior of confined self-compacting concrete under compression at elevated temperatures. *Buildings*, *13*(12), 3115. https://www.mdpi.com/2075-5309/13/12/3115

Nguyen, P. T., & Lee, K. H. (2023). Behavior of confined self-compacting concrete under compression at elevated temperatures. *Buildings*, *13*(12), 3115. https://doi.org/10.3390/buildings13123115

Okamura, H., & Ozawa, K. (1995). Mix design for self-compacting concrete. *Concrete Library of JSCE*, *25*(6), 107-120.

Phan, L. T., Lawson, J. R., & Davis, F. L. (2001). Effects of elevated temperature exposure on heating characteristics, spalling, and residual properties of high-performance concrete. *Materials and Structures*, *34*(2), 83-91.

Sideris, K. K., Manita, P., Papageorgiou, A., & Chaniotakis, E. (2003, June). Mechanical characteristics of high performance fibre reinforced concrete at elevated temperatures. In *Proceedings of international conference on durability of concrete, Thessaloniki, Greece, CANMET/ACI, SP* (Vol. 212, pp. 973-988).

Vengala, J., & Ranganath, R. V. (2004). Mixture proportioning procedures for self-compacting concrete. *Indian Concrete Journal*, *78*(8), 13-21.

Zhu, L., Zhang, F., & Li, W. (2012). A study on the mechanical properties of self-compacting concrete at high temperature and after cooling. *Materials and Structures*, *45*(6), 933-944. https://link.springer.com/article/10.1617/s11527-012-9839-9

Zhu, L., Zhang, F., & Li, W. (2012). A study on the mechanical properties of self-compacting concrete at high temperature and after cooling. *Materials and Structures*, *45*(6), 933-944. https://doi.org/10.1617/s11527-012-9839-9