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*Research Paper*

# A Critical Evaluation of Self Compacting Concrete Using Mineral Admixture

**Surinder Singh[1], Mukesh Kumar[2]**

Civil Engineering Department, Universal Group of Institutions, Punjab, India

Correspondence should be addressed to Surinder Singh;

singhsurrinder5252@gmail.com

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This research provides an experimental study on the workability measures of multiple mineral admixtures (slump, L-box, U-box and T50). The approach followed the 10 percent, 20 percent and 30 percent substitute mineral admixtures for Portland cement and output is measured and compared. It explores the impact of mineral admixtures on the workability of self-compacting concrete. The mixing ratio is obtained in compliance with the recommendations issued by the European Federation of producers and contractors of special products for structure. It is observed that the optimal dosage of super plasticizer increased the concrete's flow property. As a consequence, overall changes were observed in the flow and filling capacity of the self-compacting concrete. It is also found that the amount of superplasticizer required to attain a given fluidity is decreased where mineral admixtures are used in self-compacting concrete. The effect of mineral admixtures on the criteria for admixtures is substantially dependent on their distribution of particle size, particle form and surface characteristics.

***Keywords:*** *Self-compacting concrete, mineral admixture, workability, flow properties.*

## 1. Introduction

The emergence of self-compacting concrete (SOC), among diverse developments and advances in building materials, over the past decades been a target for the use of alternative raw materials, sub-products, waste and secondary materials as a mineral additive [1-3]. It is also known as a special concrete with better fluid characteristics, including improved fluidity and high separation power, and can be settled by its own weight with a steep strengthening in deep and narrow sections of unorthodox geometry [4,5]. Therefore, SCC will strengthen itself during the putting period and will stop segregation, bleeding and protection of its stability without using internal or external vibrations. Furthermore, the potential use of SCC in lightweight applications has been given considerable consideration [6]. SCC requires the right mixing modelling phase to achieve the desired characteristics according to their complex nature. During this design process, the available materials must be taken into account in proportion to one or more minerals and chemical admixtures [7-10]. This dilemma is overcome by an appropriate balance between the coarse and fine substances with chemicals combined with improved distribution of the grain size and mixing of particles, thus ensuring greater consolidation of SCC [11-14]. This work seeks to evaluate the variations in self-compacting concrete's current characteristics with and without a mineral admixture. The investigation is carried out with and without mineral admixtures to study the changes in the hardened characteristics of SCC.

## 2. Material and Testing

### 2.1 Material

Birla Uttam Ordinary Portland cement of grade 43 confirming to IS 8112-1989 is used along with natural river sand of size 4.75 mm and below confirming to zone 3 of IS 383-1970 is used as the fine aggregate. Natural crushed stone with 20 mm size is used as coarse aggregate. Metakaolin used in this work is obtained from Karanwal Infratech Materials Pvt Ltd. Faridabad, Haryana. The admixture used in this work is Auramix 400 complies with IS: 9103-1999 (2007). It also complies with ASTM C494 Type G depending on the dosage used. The coarse aggregates, fine aggregates, cement, water, admixture, and other mineral admixture (Fly ash, metakaolin) were weighed first with accuracy. The concrete mixture was prepared by hand mixing on a non-absorbing platform. On the non-absorbing platform, the coarse and fine aggregates were mixed thoroughly. To this mixture, the cement was added and mixed to uniform colour. Then 70 to 80 % water was added by making space in the centre and rest was sprinkled on the mix. Casting was done with varying percentage i.e., 10%, 20% & 30% respectively as replacement of cement with fly ash, and metakaolin. Various mix obtained are as given below in Table 1.

Table 1 Mix IDs with the detail of fly ash and metakaolin percentage

| S. No. | Mix ID | Details |
|---|---|---|
| 1 | CM | No substitution of FA or metakaolin |
| 2 | SCC1 | 10 % FA as concrete substitution |
| 3 | SCC2 | 20 % FA as concrete |

| | | |
|---|---|---|
| | | substitution |
| 4 | SCC3 | 30 % FA as concrete substitution |
| 5 | MET 1 | 10 % Metakaolin as concrete substitution |
| 6 | MET 2 | 20 % Metakaolin as concrete substitution |
| 7 | MET 3 | 30 % Metakaolin as concrete substitution |

FA- Fly ash; Cm- Control blend

## 2.2 Test

Number of tests are done to evaluate the performance of SCC mix. Normal Consistency test is done to determine the quantity of water required to produce cement paste of standard consistency for the use. Vicat's apparatus (IS:5513-1976) with Vicat's 50mm long plunger is used for this purpose. Slump flow test is the most commonly used tool of laboratory and construction site concrete quality measurement. This was done by measuring the sum of two diameters determined perpendicularly to determine the properties of the concrete described above. In case of no impediments, the slump flow test is used to measure the SCC's horizontal free flow. The water runs as the slumping cone is lifted, filled with lime. The average concrete circle diameter is a measure of the concrete's filling capacity. The T 50cm time is a secondary flow predictor. It estimates the time taken in seconds from the moment the cone is raised to the moment where the horizontal flow exceeds 500 mm in diameter. The flow capability of the fresh concrete is measured by means of the V-funnel test, which tests the flow time. The funnel is packed with about 12 litres of concrete, and it tests the time it takes to pass into the apparatus. Shorter flow time implies greater potential for flow. In comparison, T 5min is assessed with a V-funnel, showing a propensity for segregation in which the funnel can be refilled with concrete and allowed to settle for 5 minutes. The flow time would rise significantly if the concrete indicates segregation. The J-Ring examination entails positioning the slump cone inside a steel ring of 300 mm diameter connected to vertical reinforcement bars at sufficient spacing (the J-Ring itself). Based on the maximum size aggregate in the SCC combination, the number of bars needs to be changed. The diameter of the spread and the T-50 period are reported for the evaluation of SCC viscosity, as in the Slump Flow test. The Slump Flow/J-Ring combination test is an extension of the Slump Flow test on its own, as it also aims to determine the fresh mix's passing ability. In this respect, without isolation of paste and coarse aggregate, the SCC has to move through the reinforcing bars. The L-box test assesses the SCC's passing capacity in a confined space. A vertical arm and a horizontal arm make up the L-box. The concrete runs into the reinforcement bars, from the vertical arm and through the horizontal arm of the box. The ratio of the concrete heights at the two ends of the box, called the blocking ratio (BR), is used to determine the passing capacity with interference as BR= H2/H1 until the test is done. If the SCC has new properties that are fine, the blocking ratio is then equal to 1. Conversely, if the concrete is so rigid or segregated, the blocking factor is equal to 0. For SCC applications involving complex shapes and congested reinforcement, blocking ratio is useful. The U-Box test is one of the test methods used to determine self-compatibility. Owing to the limited volume of concrete used, the U-type test offered by the Taisei Party is the most suitable relative to others (Ferraris, 1999). The apparatus consists of a vessel which is separated into two compartments by a middle wall. It gives a strong direct evaluation of passing ability. The degree of compaction potential can be shown in this test by the height achieved by the concrete after flowing through obstacles. It is possible to classify concrete with a filling height of over 300 mm as self-compacting. If the filling height is greater than 85 percent of the highest height possible, some businesses deem concrete self-compacting.

# 3. Results and Discussion

## 3.1 Results of slump Flow Test

The greater the importance of the slump flow, the greater its capacity to fill forms under its own weight. For SCC, a value of at least 650mm is required. There is no widely agreed advice about what tolerances are acceptable for a given value, while ± 50 mm might be sufficient, as in the related flow table test. A secondary indicator of flow is the T50 time. Higher flow-ability suggests a lower period. Many coarse aggregates would reside in the middle of the concrete and mortar paste reservoir at the concrete perimeter in the event of segregation. The results of the slump-flow experiments are seen in Table 2. The shift in slump flow for various mixes evaluated during the current analysis as seen in Figure

1.

Table 2 Slump flow test for filling ability

| Mix ID | Slump (mm) |
|---|---|
| CM | 680 |
| SCC-1 | 675 |
| SCC-2 | 685 |
| SCC-3 | 690 |
| MET-1 | 700 |
| MET-2 | 714 |
| MET-3 | 721 |

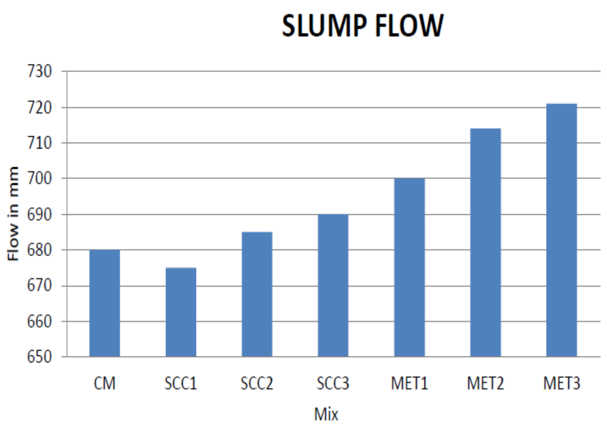


Figure 1 Showing slump flow variation

## 3.2 Results of V-Funnel Test

This test evaluates the ease of flow of concrete; greater flow capacity is shown by shorter flow periods. A flow time of 10 seconds is considered optimal for SCC. The inverted cone form limits flow, and some hint of the mix's susceptibility to blocking can be provided by extended flow periods. For a rise in flow time, segregation of concrete would demonstrate a less steady flow after 5 minutes of settling. The difference in the findings observed during the V-Funnel test conducted on various SCC mixtures as seen in Table 3 and Figure 2.

Table 3 V-funnel test for filling ability

| Mix ID | V-Funnel (sec) |
|---|---|
| CM | 7.2 |
| SCC1 | 7.6 |
| SCC2 | 7.6 |
| SCC3 | 8.0 |
| MET-1 | 8.2 |
| MET-2 | 8.4 |
| MET-3 | 8.9 |

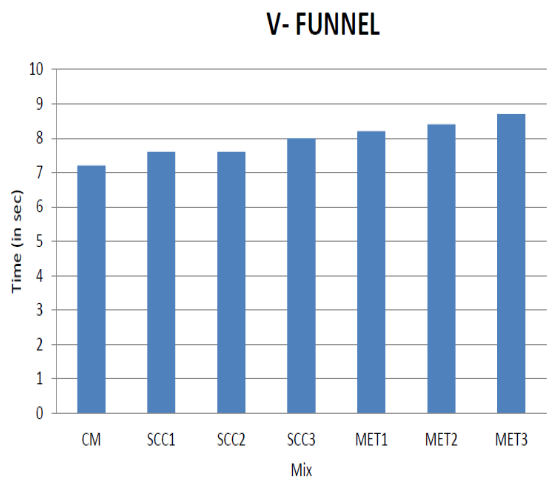


Figure 2 Showing variation in V- funnel time

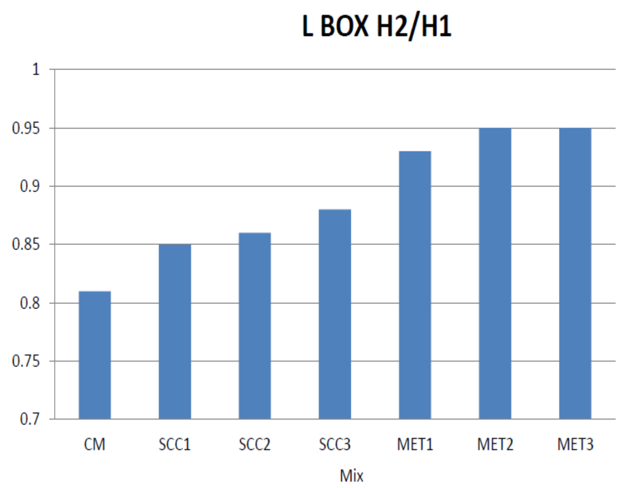


Figure 3 showing L box results

### 3.3 Results of L-Box Test

It would be horizontal at rest if the asphalt flows as naturally as water, then H2/H1 = 1. Therefore, the closest this test value is to unity, the higher the concrete flow, the 'blocking ratio'. Any indicator of ease of flow may be given by T20 and T40 periods, but no acceptable values have usually been accepted. It is necessary to carry out the entire test within 5 minutes. The findings of the L-Box evaluation are shown in Table 4 and Figure 3.

Table 11 L box test for passing ability

| Mix ID | L-Box(H2/H1) |
|---|---|
| CM | 0.81 |
| SCC1 | 0.85 |
| SCC2 | 0.86 |
| SCC3 | 0.88 |
| MET-1 | 0.93 |
| MET-2 | 0.95 |
| MET-3 | 0.95 |

### 3.4 Results of U-Box Test

If the concrete circulates as freely as water, it would be horizontal at rest, so H1-H2 = 0.0. Therefore, the lower this measure value is to 0, the greater the concrete's flow and passing capacity is. The effects of the U-Box test on various SCC mixtures can be seen in Table 12 and Figure 4.

Table 12 U box test for passing ability

| MIX ID | U BOX (H2-H1) |
|---|---|
| CM | 30 |
| SCC1 | 30 |
| SCC2 | 27 |
| SCC3 | 26 |
| MET-1 | 24 |
| MET-2 | 21 |
| MET-3 | 20 |

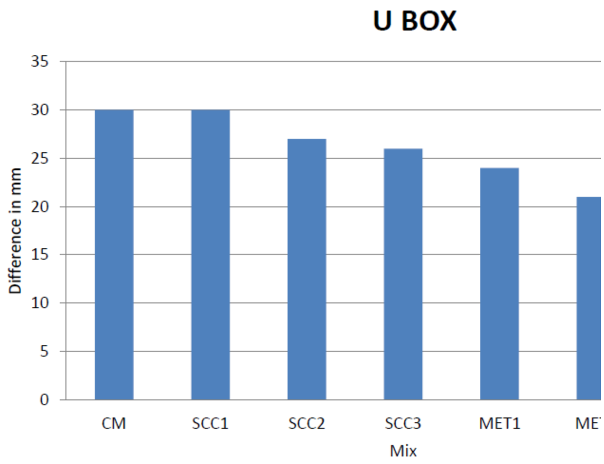

Figure 4 Showing U box result

## 4. Conclusion

The new scientific research is conducted on the refreshing properties and hardening properties of fly ash and metakaolin incorporating self-compacting concrete. SCC blends incorporating up to 30 percent fly ash may be designed. All SCC mixes with fly ash have fresh concrete property values, i.e., slump flow, V-funnel, L-Box, U-Box. SCC with metakaolin demonstrates acceptable workability outcomes and Metakaolin achieves the optimum performance of 30 percent cement substitution, which illustrates good workability and strength as well.

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