EFFECT OF BINDER CONTENT ON SUPER PLASTICIZER DOSAGE FOR SELF-COMPACTING CONCRETE

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Abstract

The most incredible inventions in concrete is Self-Compacting Concrete, i.e. concrete will flow by its own weight. Self-compacting concrete can be achieved by high powder content and with combination of different mineral admixtures or secondary supplementary cementitious materials, high range water reducing super plasticizers and the performance of concrete will also enhanced. All above mentioned qualities make Self-compacting concrete as Special concrete. The more research works were going on to get the generalized mix code for SCC and effect of each ingredient of concrete also examine for SCC. In the present study, the effect super plasticize dosage and binder content on properties of Self-Compacting Concrete (SCC) had been studied. As a part of experimental study, the mix design was developed based on EFNARC guidelines. The SCC mixes were made with different proportion of binder content (450, 500, 550) at various dosages of super plasticize. Slump flow, V-funnel, l-box and J-ring tests were conducted for checking the properties of SCC. 3-days, 7-days, 28-days UPV test was conducted. The experimental results reveal that at higher binder content, at lower dosage, SCC was formed. The strength was achieved M45, M60 with 500 and 550 grades of cement respectively.

Keywords: Self-compacting concrete, binder content, Super plasticizer dosage, mix design.

I. Introduction

Self-compacted concrete (SCC), concrete flows by it’s own weight, is the most emerging innovation in concrete industry, to enhance the performance of...
concrete. The inherent properties of self-compacting concrete are flowing ability, filling ability, passing ability without any segregation. Due to huge advantages the SCC used for various structural applications, repairs applications, and restricted areas [IV],[III],[I]. In the last of 20th century, the chemical admixtures were invented for concrete to reduced water demand and subsequently, the steps were formed to develop the SCC [VI]. The self-compacted concrete is advent in the 21st century to solve the problems encounter due to poring of concrete at restricted areas like tunnels, viaducts, heavy congested reinforcement. Japan is the first country who made SCC first time in the world[V]. The initial research was carried on development of workability of SCC by Omkura, Ozawa and Maekaewa in University of Tokyo[VIII]. Self-compacting concrete is a special type of concrete. Hence, Proper mix design code is not available to make proportions. Only by trial and error method is adopting to get the proportion and cross check with the EFNARC guidelines. As per guidelines, SCC demands the high powder content, less proportion of coarse aggregate. High cement content may lead to drying shrinkage and other environmental related problems will be encountered, therefore the incorporation of mineral admixtures such as fly ash, lime stone powder, rise husk ash, GGBS, etc, reduces the shrinkage problems and also improve the fine fraction i.e. less than 0.125 microns, which will improve the viscosity of concrete at low water demand. Mineral admixtures are also improving the strength and durability by improving the Interfacial Transition Zone [IX,II]. So, each ingredient can alter the properties of concrete significantly especially, in Self-compacting concrete. Hence, the researchers are working on to develop a generalized code for SCC. In this regard, omkura et.al first developed the mix design for SCC and later Nan su was introduced the other method[VII].

Objective of Research

1. To obtain the optimum Super plasticizer dosage at different binder content and its influence on properties of SCC
2. To study the effect of binder content on properties of self-compacting concrete and compressive strength of concrete.
3. The effect of binder content on quality of concrete

II. Materials Used

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Hyper fluid flow
5. C-flow-251N
6. Water
Table 1: Cement Characteristics

| Characteristic         | Value   |
|------------------------|---------|
| Normal consistency     | 34%     |
| Initial setting time   | 45 min  |
| Final setting time     | 10 hours|
| Specific gravity       | 2.94    |

Table 2: Fine aggregate (River Sand) Characteristics

| Zone of sand | Zone II |
|--------------|---------|
| Specific gravity | 2.6    |
| Fineness Modulus | 2.4    |

Table 3: Coarse aggregate Characteristics

| Max. Size of aggregate | 20 mm  |
|------------------------|--------|
| Specific gravity       | 2.8    |
| Fineness Modulus       | 7.36   |

III. Methodology

Self-compacting concrete is a complex material because of many ingredients. Hence, it is difficult to obtain the desired proportions. In the first stage, the self-compacting concrete was prepared and assessed the properties with the CAC admixture and in the second stage, with the C-flow-251N super plasticizer. For the fresh properties, slump flow, v-funnel, l-box and j-ring test were conducted. For hardened properties, compressive strength test was conducted. To check the quality of concrete, UPV test was conducted. Mix proportion details were given in Table 4.

Table 4: MIX PROPORTIONS

| Mix | Cement (kg/m³) | GGBS (kg/m³) | F.A (kg/m³) | C.A (kg/m³) | Water (kg/m³) | S.P Dosage |
|-----|----------------|--------------|-------------|-------------|---------------|------------|
| TM1 | 382.5          | 67.5         | 1049.4      | 732.6       | 206           | 0.4        |
| TM2 | 382.5          | 67.5         | 1049.4      | 732.6       | 206           | 0.6        |
| TM3 | 382.5          | 67.5         | 1049.4      | 732.6       | 206           | 0.7        |
| TM4 | 382.5          | 67.5         | 1049.4      | 732.6       | 206           | 0.8        |
| TM5 | 382.5          | 67.5         | 940.08      | 804.95      | 200           | 0.6        |
| TM6 | 382.5          | 67.5         | 940.08      | 804.95      | 200           | 0.8        |
| TM7 | 382.5          | 75           | 906.56      | 804.95      | 200           | 1          |
| TM8 | 425            | 75           | 906.56      | 804.95      | 206.4         | 0.5        |

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IV. Results and Discussion

Table 5: Fresh properties of SCC

| Trial mixes (mm) | S.P Dosage | Slump flow (mm) | J-ring (cm) | V-funnel (sec) | L-box | Remarks |
|------------------|------------|----------------|-------------|----------------|-------|---------|
| TM-9             | 425        | 75             | 906.56      | 776.25         | 206.4 | 0.6     |
| TM-10            | 425        | 75             | 906.56      | 776.25         | 206.4 | 0.8     |
| TM-11            | 425        | 75             | 906.56      | 776.25         | 206.4 | 1       |
| TM-12            | 467.5      | 82.5           | 878.87      | 752.24         | 208   | 0.5r    |
| TM-13            | 467.5      | 82.5           | 878.87      | 752.24         | 208   | 0.55    |
| TM-14            | 467.5      | 82.5           | 878.87      | 752.24         | 208   | 0.6     |

*Note: TM- Trail Mix*

From the table-5, fresh properties tests results reveal that, from Mix 1-4, with the CAC super plasticizer not given the satisfactory results. From mix 5-14, With C-flow-251N super plasticizer were given satisfactory results. As binder content increases the self-compacting concrete formed at lower dosages. For 450, 500, 550 binder contents, the fresh properties of SCC satisfied at 1, 0.8, 0.7 respectively. With 500 and 550 binder content, the properties of SCC almost achieved at dosages of super plasticizer.
Compressive test:

Table 6: For 450 binder content (w/b = 1.2)

| S. No | S.P Dosage | Compressive strength |
|-------|------------|----------------------|
|       |            | 3-dyas   | 7-days   | 28-days   |
| 1     | 0.4        | 15.55    | 20.6     | 36.05     |
| 2     | 0.6        | 19.07    | 25.35    | 45.98     |
| 3     | 0.7        | 17.24    | 23.15    | 42.32     |
| 4     | 0.8        | 13.12    | 25.67    | 36.63     |

Fig. 1: Compressive test results for 450 binder content (w/b = 1.2)

The table-6, the values of compression test of 3, 7, 28 days. From the figure 1, With 450 binder content and CAC super plasticizer, the strength of concrete increases with the dosage of super plasticizer up to 0.6% and then decreases due to bleeding and segregation. Strength was achieved up to M40 grade of concrete.

Table 7: For 450 binder content (w/b = 1.3)

| S.No. | S.P DOSAGE | Compressive test |
|-------|------------|-------------------|
|       |            | 3-dyas  | 7-days  | 28-days  |
| 1     | 0.6        | 18.05   | 28.73   | 45.42    |
| 2     | 0.8        | 17.6    | 25.7    | 42.21    |
| 3     | 1.0        | 16.01   | 24.3    | 40.16    |
From the figure 2, with 450 binder content and C-flow-251N super plasticizer, strength was achieved up to M40 grade of concrete.

**Table 8: For 500 binder content (w/b =1.2)**

| S. No | S.P Dosage | Compressive test |
|-------|------------|------------------|
|       |            | 3-dyas | 7-days | 28-days  |
| 1     | 0.5        | 38.5    | 37.3    | 42.47    |
| 2     | 0.6        | 25.84   | 45.56   | 51.76    |
| 3     | 0.8        | 29.7    | 43.3    | 54.11    |
| 4     | 1.0        | 27.8    | 36.64   | 50.84    |

**Fig. 2:** Compressive test results for 450 binder content (w/b =1.3)

**Fig. 3:** Compressive test results for 500 binder content (w/b =1.2)
From the figure 3, With binder content 500, the strength was achieved up to M45 grade of concrete. The strength values were continuously increasing from 0.5 to 0.8 % dosage of Super plasticizer and decreased at 1% admixtures dosage.

Table 9: For 550 binder content (1.1)

| S. No. | S.P DOSAGE | Compressive test |
|--------|------------|------------------|
|        |            | 3-dy | 7-days | 28-days |
| 1      | 0.5        | 29.7  | 49.44  | 68.33   |
| 2      | 0.55       | 27.8  | 52.82  | 75.33   |
| 3      | 0.6        | 38.5  | 54.92  | 65.87   |

Ultrasonic Pulse Velocity Test:

Table 10: For 450 binder content (w/b = 1.2)

| S.No. | S.P DOSAGE | UPV test |
|-------|------------|----------|
|       |            | 3-dy | 7-days | 28-days |
| 1     | 0.4        | 3.15  | 3.38   | 4.28    |
| 2     | 0.6        | 3.32  | 3.07   | 4.43    |
| 3     | 0.7        | 3.12  | 3.12   | 4.11    |
| 4     | 0.8        | 3.27  | 3.32   | 3.32    |

Fig. 5: UPV test results for 450 binder content (w/b = 1.2)
Table 11: For 450 binder content (w/b = 1.3)

| S.No. | S.P DOSAGE | UPV test | 3-dyas | 7-days | 28-days |
|-------|------------|----------|--------|--------|---------|
| 1     | 0.6        | 3.17     | 3.68   | 3.68   |
| 2     | 0.8        | 3.28     | 3.4    | 3.4    |
| 3     | 1.0        | 3.3      | 3.62   | 3.62   |

Fig. 6: UPV test results for 450 binder content (w/b = 1.3)

Table 12: For 500 binder content (w/b = 1.2)

| S.No. | S.P DOSAGE | UPV test | 3-dyas | 7-days | 28-days |
|-------|------------|----------|--------|--------|---------|
| 1     | 0.5        | 3.15     | 3.7    | 4.48   |
| 2     | 0.6        | 3.7      | 3.42   | 3.42   |
| 3     | 0.8        | 3.42     | 3.73   | 3.73   |
| 4     | 1.0        | 3.73     | 4.29   | 3.15   |
From the UPV test, the values fall within the range of 3.30-4.40, that means all the concrete mixes quality is excellent. However, the values of 450 binder content with w/b=1.3, mix results were shown the good quality of concrete. The UPV values are less than the all mix values due to bleeding and segregation.
V. Conclusion

From the experimental results of all trial mixes the following conclusions were made.

- Minimum water 200kg/m$^3$ should be maintained in order to achieve self-compacting concrete.
- Poly carboxlic ethane (PCE) super plasticizer will give better SCC properties at lower dosages.
- At higher dosages, flow ability were improved however, passing ability and filling ability was failed.
- From the all the trial mixes, the trial mix 12, 13, 14 (with 550 binder content) was shown the better performance and satisfies the all properties of Self-compacting concrete.
- From the compression test, it reveals that, with 450kg/m$^3$ 500kg/m$^3$, 500 kg/m$^3$ binder content, M35, M45, M60 grade of concrete was achieved respectively.
- From the Ultrasonic pulse velocity, all the concrete cubes shown the value between the ranges of 3.05-4.4. It indicates that good quality of concrete was achieved. Therefore, as binder content increases the strength, quality of concrete also increased.
- The influence of admixture on strength of concrete is not very much, only marginal variation was observed.

References

I. B.Łaz’niewska-Piekarczyk, “The influence of chemical admixtures on cement hydration and mixture properties of very high performance self-compacting concrete”, Construction and Building Materials, Dec. 2013.

II. B. Beeralingegowda and V. D. Gundakalle, “The effect of addition ofLimestone powder on the Properties of self-compactingConcrete”, International Journal of Innovative Research in Science, Engineering and Technology, vol. 2, no. 9, Sep. 2013.

III. B. G. Patel, A. K. Desai and S. G. Shah, “Effect of Binder Volume on Fresh and Harden Properties of Self Compacting Concrete”, International Journal of Engineering Research & Technology, vol. 4, no. 09, Sept. 2015.

IV. H. Omkura and M.Ouchi, “Self-compacting concrete”, journal of Advanced Concrete Technology, vol. 1, no.1, pp. 5-15, Apr. 2003.
V. L.O Larsen and V.V. Naruts, “Self-compacting concrete with limestone powder for transport infrastructure”, Magazine of Civil Engineering, vol. 68, no. 8, pp. 76-85, 2016.

VI. M. A.Sikandar, Z.Baloch and Q. Jamal, “Effect of w/b ratio and binder content on the properties of self-compacting high-performance concrete (SCHPC)”, Journal of Ceramic Processing Research, vol. 6, no. 1, pp. 40-48, Jan. 2018.

VII. P.Aggarwal, R.Siddique, Y.Aggarwal and S. M. Gupta, “Self-Compacting Concrete - Procedure for Mix Design”, Leonardo Electronic Journal of Practices and Technologies, no. 12, Jan-Jun 2008, pp. 15-24.

VIII. P. D Viramgama, Prof. S. R. Vaniya and Prof. Dr. K.B.Parikh, “Effect of Ceramic Waste Powder in Self Compacting Concrete Properties: A Critical Review”, IOSR Journal of Mechanical and Civil Engineering, vol. 13, no. 1 Ver. V, Jan. - Feb. 2016.

IX. S.Grzeszczyk and P.Podkowa, “The Effect of Limestone Filler on the Properties of Self Compacting Concrete”, Annual Transactions of The Nordic Rheology Society, vol. 17, 2009.