ELK
Asia Pacific Journals

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-5-4

A STUDY ON SIMPLIFIED MIX DESIGN OF SELF COMPACTING CONCRETE

NIMMAGADDA SAI CHANDRIKA	CHAVA SRINIVAS
(civil engineering, Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada, India, sona.nimmagadda93@gmail.com)	(civil engineering, Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada, India, chavasrinivas@yahoo.co.in)

ABSTRACT

Self Compacting Concrete is a concrete which can easily flow and compact under its own weight. It can also fills in the restricted sections without any additional compaction, machinery and it maintains uniformity. It can be placed at a faster rate which results in shorter construction period, cost savings and labour savings. At Present mix design procedures proposed by NANSU from Taiwan, OKAMURA and OZAWA from Japan are in use. This study is a simplification of the mix design procedure for self compacting concrete. The general mix design proposed by NANSU to achieve SCC properties is difficult to adopt. In this study the simplification of the mix design is done by considering IS code – IS 10262 and by altering the fine aggregate and coarse aggregate to 52% and 48% respectively, The S.C.C properties and strength are achieved and Super plasticiser is added to increase the flow ability in addition to this fly ash is added with equivalent weight of cement to increase the powder content. The concrete obtained with the above modifications satisfies the EFNARC guidelines. This procedure can be obtained by the non-technical persons and best alternative for simplification of mix design of S.C.C. Tests are conducted to verify the properties of S.C.C. This is useful for all types of construction works.

Keywords: Self compacting concrete, SCC, Simplified, Fly ash

Introduction

Concrete that is able to flow easily and can also compact under its own weight is known as self-compacting concrete. This self-compacting concrete maintains homogeneity without the need of any other additional compaction equipment and can also completely fill in the formwork even in the presence of dense reinforcement. It has proved beneficial and economical because of speed construction, reduces site manpower, easier in placing, improves durability, gives good surface finish, workability increases, absence of vibration, and reduces noise pollution. Mix design for self-compacting concrete is made easier by considering some changes from IS 456-2000 and altering the fine aggregate and coarse aggregate percentages to 52% and 48% respectively as the coarse aggregate content should not exceed 50% of the total aggregate content so the proportion is altered this obeys all the guidelines to be followed for SCC from EFNARC and tests for SCC are conducted.

1. **Advantages of self compacting concrete**
   - 1.1 Vibration is not required Self compacting concrete can be placed easily.
   - 1.2 It can be placed in congested sections.
   - 1.3 No requirement of compaction.
   - 1.4 Vibration machinery is not required.
   - 1.5 Decreases noise pollution.
   - 1.6 Cost of construction is less because of no vibration and less construction period.
   - 1.7 Good surface finish.
   - 1.8 Improves bonding with the reinforcement and consolidation around reinforcement.
2. **ARCHITECTURAL ADVANTAGES:**
   - 2.1 Homogeneity and uniformity in concrete
   - 2.2 Concrete flows easily into any complex shapes through congested reinforcement

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-5-4

2.3 High strength and durability
2.4 Useful in innovative architectural features

3. TESTS:

3.1 SLUMP FLOW TEST:

3.1.1 The slump flow test is the process to assess the horizontal flow of concrete in the absence of obstructions. It indicates the resistance to segregation and it also gives filling ability.

3.1.2 EQUIPMENT:

- The slump cone with base diameter of 200 mm, top diameter 100mm and height 300mm
- A square shaped base plate.
- Centre point is marked to place the slump cone.
- A circle is drawn at 500 mm diameter.
- Trowel.
- Measuring tape
- Stop watch

3.1.3 PROCEDURE:

Place the base plate on a level ground. Keep the slump cone at the centre and Fill the cone with concrete. Tampering should not be done. Strike off the concrete level with the trowel. Remove the excess concrete on base place. Raise the cone vertically up and allow the concrete to flow freely. Measure the final diameter of the concrete flow in the two perpendicular directions and calculate the average of the two perpendicular diameters. It gives the slump flow in mm. no water, cement paste, mortar without coarse aggregate is seen at the edge of the concrete.

3.1.4 INTERPRETATION:

If the value is high it gives greater ability to fill in the form work with its own weight. 650mm value is generally required. If the coarse aggregate remains at the centre and mortar, paste flows then it indicates that the segregation is high.

3.2 V-FUNNEL TEST

3.2.1 The V- Funnel test is used to determine the filling ability of the concrete. The funnel is filled with concrete and the time taken for concrete to flow down is noted. After this the funnel again filled with concrete and left for about 5 minutes to settle. And then if the concrete shows segregation then the flow time will increase significantly.

3.2.2 APPARATUS:

- V-funnel
- Bucket
- Trowel
- Stopwatch

3.2.3 PROCEDURE:

Place the V-funnel on a level ground. Moisten inside of the funnel. Remove the excess water present in it. Close the trap door and place a bucket under it. Fill the apparatus completely with concrete. No compaction or tamping is done. Strike off the concrete level with trowel.

Open the trap door within 10 seconds and record the time taken for the concrete to flow down and also record the time of flow for emptying the funnel. The whole test should be performed within 5 min.

PROCEDURE (flow time at 5min) :

Do no clean inner surface of the funnel. Close the trap door and again fill in the V-funnel immediately after measuring the flow time. Place the bucket at the bottom. Fill the apparatus completely with concrete without tamping and Strike off the concrete level by trowel. Open the trap door after 5 minutes after the filling the funnel and allow the concrete to flow down. Calculate the time taken for complete discharge. This

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-5-4

is called as flow time at 5 min. For V-funnel test the flow time should be between 8 and 12 seconds. At 5 min test + 3 seconds is allowed.

3.3 L-BOX TEST:

3.3.1 The test is to access the flow of concrete, and also the extent to which the concrete is subjected to blocking by reinforcement.

3.2.2 APPARATUS:

- L-box with sliding gate
- Trowel
- Stop watch

3.3.3 PROCEDURE:

Place the L-box on a level ground and the sliding gate should opened and closed freely. Moisten the inside surface, remove the excess water. Fill the vertical section of the apparatus with the concrete. Leave it for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. Simultaneously start the stopwatch and record the time taken for the concrete to reach the horizontal section. When the concrete stops flowing, the height H1 and H2 are measured.

The blocking ratio H2/H1 is calculated. The whole test should be performed within 5 minutes.

3.3.4 INTERPRETATION:

If the concrete flows as freely as water, at rest it will be horizontal. Therefore H_2/H_1 will be equal to 1. Therefore nearer the test values, the blocking ratio is to unity, the better the flow of concrete. The European Union research team suggested a minimum acceptable value of 0.8.

4 LITERATURE:

4.1 OKAMURA AND OZAWA:

C.A content not to exceed 50% of the solid volume

4.2.2 Sand content on volume basis not to exceed 40% of mortar volume.

4.2.3 Water, powder ratio on a volume basis of 0.9 to 1.1 depending upon the properties of the powder.

4.2 EFNARC:

4.2.4 water/powder ratio by volume 0.8-0.9

4.2.5 total powder content is 400-600kg/cubic meter

4.2.6 coarse aggregate content normally 28-35% by volume of mix

4.2.7 Water: cement ratio is selected based on requirements in EN206. Typically water content does not exceed 200ltr/cubic meter.

4.2.8 The sand content balances the volume of the other constituents.

This paper gives the simplest form of mix design for self compacting concrete by following all the guide lines of EFNARC, OKAMURA and OZAWA. This procedure makes use of normal concrete mix design as it can be easily adopted.

5 PROCEDURE:

5.1 MIX DESIGN

5.1.1 MATERIALS:

- Cement- OPC 53 grade
- Coarse aggregate- 12 mm
- Fine aggregate-zone 3
- Water

Maximum size of coarse aggregate=12mm

5.1.2 TARGET STRENGTH FOR MIX PROPORTIONING

$f'_{ck} = f_{ck} + 1.65 \times s$

Where s, standard deviation= 4

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-5-4

f'_{ck} = 20+(1.65×4) = 26.6N/mm2

5.1.3SELECTION OF WATER-CEMENT RATIO:

From table-5 of IS-456:2000

Maximum water cement ratio =0.55

Adopting w/c =0.5

5.1.4SELECTION OF WATER CONTENT:

From table-2, IS-10262:2009

For 50mm slump water content=186ltr

Assume slump of 100mm =

$$\frac{186}{((3 \times 2) \div 100) \times 186}$$

=197.16ltr (cl-4.2, IS-10262)

As super plasticizer is used, reduce water content by 25%

So water content = 147.87ltr

5.1.5 CALCULATION OF CEMENT CONTENT :

W/C = 0.5

Cement content = $\frac{water}{0.5}$

$$= \frac{147.87}{0.5}$$

$$= 295.74 kg/m^3$$

As per IS-456, minimum water content=300 kg/m^3

So cement content = 300 kg/m^3

Revised water content = 0.5×300 = 150ltr

5.1.6PROPORTION OF VOLUME OF COARSE AND FINE AGGREGAE CONTENT:

- Volume of coarse aggregate for w/c=0.5, 12mm=0.62
- Volume of fine aggregate= (1-0.62)

=0.38

5.1.7MIX CALCULATIONS:

- Volume of concrete=1 m^3
  Volume of cement
  $$= \frac{M\,c}{G * \rho\, W}$$
  $$= \frac{300}{3.15*1000}$$
  $$= 0.0952$$
- Volume of water= $\frac{150}{1000}$
  $$= 0.15$$
- Volume of all in aggregate=(1-0.0967 – 0.15) = 0.753
- Mass of coarse aggregate=(0.62× 0.75×2.7×1000)= 1260.5kgs
- Mass of fine aggregate = 0.38×0.753×2.7× 1000 = 744kgs
- Mix proportion for $1m^3$ = 300:744:1260
- Basic proportion=1:2.48:4.2
- Coarse + fine aggregate = (2.48+4.2) = 6.68
- Altered proportion = 1: (6.68×0.52): (6.68×0.48) = 1:3.47:3.2
- Addition of 100% Fly Ash
- Mix proportion= fly ash: cement: aggregate: fine aggregate =1:1:3.47:3.2
- Volume of cement= $\frac{300}{3.15\times1000}$
  $=0.0842m^3$
- Fly ash =$\frac{265.23}{2.6\times1000}$ = $0.1020m^3$
- Total volume of powder
  = 0.0842+0.1020 = $0.1862m^3$
- Volume of fine aggregate = $\frac{1041}{1000\times2.6}$
  $= 0.4m^3$
- Volume of coarse aggregate
- = $\frac{960}{2.7\times1000} = 0.355$

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-5-4

for 100% addition of fly ash the volume will be increased so the volume is considered as 0.885, the volume of fine aggregate and coarse aggregate contents are decreased to0.354 and0.3146 respectively.

5.1.8 CHECKS:

- C.A<50%

$$= \frac{0.3146}{(0.3146+0.1862+0.354+0.15)\times 100}$$

= 31.3% < 50% (hence ok)

- Sand > 40% of mortar

$$= \frac{0.354}{0.354+0.1862+0.15))\times 100}$$

51.289%>40% (hence ok)

- $\frac{water}{powder} = \frac{0.15}{0.1862}$
  = 0.805 (hence ok)
- Total powder content = 530.46kgs.
- Water content = 150ltr

The above concrete mix is tested to check all the properties of self compacting concrete. slump flow test, L-box test, V-funnel test to check the passing ability, filling ability, flow ability. The test results satisfied all the properties of self compacting concrete.

6 Figures and Tables

VALUES FOR TESTS

Test	Test values for Nansu method	Test values
Slump flow test	650mm	680mm
L- box	0.8-1	0.8
V- funnel	8-12sec	10sec

The estimated strength of concrete is obtained by the above mix design procedure so it can be easily altered and can be adopted easily

7 Conclusion

The use of this concrete in site is easier but because of complicated mix design it cannot be easily adopted by the general laymen and requires skilled person this paper gives the new mix design for concrete which is made easier and can be easily adopted, this concrete can be used for all types of civil engineering works. The test values for the new mix design procedure are satisfying all the properties of the self compacting concrete and the values obtained after conducting tests are same as the other mix design procedures so it can be easily adopted.

8 References

Journal Papers:

[1] Chava Srinivas, Gopala Krishnayya and Raju P.S.N ICACC 2004"effect of flyash addition on compressive strength, stress strain behaviour and durability of concrete exposed to sulphuric acid", international conference on advances in concrete and construction.

[2] Hajime Okamura and Masahiro Ouchi, (APRIL 2003) journal of advanced concrete technology.

[3] Krishna Murthy.N, Narasimha Rao A.V, Ramana Reddy I.V and Vijaya sekhar Reddy.M, Mix Design Procedure for Self Compacting Concrete, Journal of Engineering.

[4] Okamura H, Ozawa K. (1995) Mix design for self-compacting concrete. Concrete Library of Japanese Society of Civil Engineers

[5] Okamura H, Ouchi M. (1999). Self-compacting concrete development, present use and future. France.

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-5-4

[6] Okamura H., Ozawa K, (June 25, 1995) Mix Design for Self-Compacting.

[7] Dakshina Murthy, Sudheer Reddy, Moment-Curvature Characteristics of ordinary grade Fly Ash Concrete beams Concrete, Concrete Library of Japanese Society of Civil Engineers

9 Books:

EFNARC (European Federation of national trade associations representing producers and applicators of specialist building products), (February 2002), Specification and Guidelines for self- compacting concrete, Hampshire, U.K.