Experimental Studies on M35 Grade Self Compacting Concrete

Mallesh M., Praveen S, Reena K, H. Eramma

***Abstract*—A Self compacting concrete concrete (SCC) is the one that can be placed in the form and can go through obstruction by its own weight and without the need of vibration. Since its first developed in Japan in 1988.In this present experimental work a simple use mix design procedure is proposed by Nan –su was used to calculate material required for SCC mix by changing the Nan –su coefficients and W/C ratio to achieve M35 grade SCC. In the SCC fly ash used as a filler material along with OPC 43 grade cement. To satisfy self compacting concrete mixes, slump flow , v-funnel flow, L-box , U-box, tests were conducted on fresh obtained and checked against the specification are given by the EFNARC guidelines. It has been concluded that for Nan-Su coefficients 10 at W/C ratio =0.44 for M35 grade SCC is achieved by satisfying all the requirements of EFNARC guidelines, strength criteria, and also satisfies the durability criteria as per IS 456-2000.**

***Index Terms*— Self compacting concrete, Nan-Su coefficient, water-cement ratio, fly ash, Auromix-400 super plasticizer, compressive strength.**

I. INTRODUCTION

Self-Compacting Concrete (SCC) is a special kind of innovative concrete, which is exceedingly foldable and non-segregating concrete, and can be easily placed and compacted under its own self weight need not requiring any mechanical vibration due to its good deformability nature and also as it acquire a property called capability of flowing through thin openings or extremely congested reinforcement structures. Self-compacting concrete is world widely abbreviated by an acronym SCC. SCC is also otherwise called as High-Fluidity Concrete, Self-Leveling Concrete and Self- Consolidating Concrete.

SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. As the durability of concrete structures became an important issue in Japan, an adequate compaction by skilled labors was required to obtain durable concrete structures. However, the gradual reduction in the number of skilled workers in Japan's construction industry has led to a similar reduction in the quality of construction work. This requirement lead to the development of SCC and its development was first reported in 1989. SCC is another sort of High Performance Concrete (HPC). It has got an excellent capability to fill up formwork and encapsulated congested reinforced steel bars by the effect of gravitational force and de-aerates completely in formwork while flowing with maintained homogeneity. The necessity of this type of concrete was proposed by Okamura in 1986. Studies to develop self-compacting concrete, including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo

Basic principles and requirements of SCC

SCC consists of materials like water, aggregates, additives, mineral admixtures, superplasticisers, used for the slowdown of the liquidity for the best work process. The following properties are fulfilled for the requirements for all properties of SCC.

a) Filling ability: It is the property of SCC which can flow easily into all closely bunched reinforcements under its self weight without bleeding and segregation .as it is highly fluid material it has got the ability to flow easily through a long distance both in horizontal and vertically.

b) Passing ability: The flow of SCC through the congested openings between reinforcing bars under its own weight without blocking or segregation. Which can be accomplished by using U-box methods.

c) Segregation resistance: it is the properly that characterizes the ability of the SCC to avoid the segregation of its components, such as the coarse aggregates. Such a property provides uniformity of the mixture during transport, placement and consolidation.

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Based on the EFNARC guidelines some of the available fresh property tests such as slump flow, V-funnel, L-box and U-box tests were conducted to evaluate the fresh properties. EFNARC specifications for SCC workability tests requirements in fresh state are given below in table 1.

Table 1: Requirements of SCC given by EFNARC Guidelines

Workability Test	Units	EFNARC Guidelines
Slump flow(dia)	Mm	650-800
U-Box(h2-h1)	Mm	0-30
L box(H2/H1)		0.8-1
V funnel (time of flow)	Sec	8-12

II. LITERATURE REVIEW

A. In 2001, Nan-Su e al proposed a suitable mix design in SCC . They suggest aggregate packing factor and aggregate content rises the strength . using of high amount of sand and less coarse aggregate helps in passing all the gaps of reinforcement.

B. B.V.B Rai et al did an investigation on SCC. the cost of ingredients of NSC/HSC and SCC differ marginally SCC materials cost just percent higher. with a view to arrive at proper comparison , a mix was proposed to make SCC have the same target strength of 40 MPA high strength concrete

C. In 2013 Prajapati Krishnapal et al carried out experimental studies on SCC using various percentages of fly ash, 10 %, 20%, and 30%, by weight of cement partial replacements of cement. Compressive strength test were carried out to know properties at the age of 7 and 28 days of curing

D. In 2014 Reena k et al did an Investigation on easy procedure published by Nan su was used by changing the Nan su coefficient for calculating the cement content i.e. C=7f!c and water cement ratio to achieve M20 grade SCC

III. METHODOLOGY

Nan-Su mix design method: It is considered to be the very simple and easy method and therefore is utilized for designing SCC mix of M35 grade in this experimental work. This mix design method was invented in Taiwan by Nan-Su. The step by stop procedure is represented as below in flow chat.

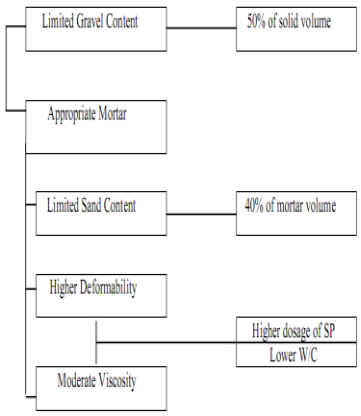

Fig 1: Methods for achieving self-compatibility

Nan-Su mix design method steps
Step1: Estimation of amount of coarse and fine aggregates for each mix.
Step2: Quantity of cement required for the SCC mix.
Step3: Estimation of required water content by the cement.
Step4: Estimation of quantity of filler material.
Step5: Total water content required for SCC mix.
Step 6 : Quantity of superplasticizer dosage.
Step 7: Trial mixes and tests on SCC properties.
Step 8 : Adjustment of mix proportions.

Nan-Su mix design method was used to prepare trial mixes for M35 grade SCC for different Nan-Su coefficients like 7, 8, 9, 10, and 11 to calculate cement content by varying water-cement ratio and keeping all other parameters like fine aggregates, coarse aggregates and dosage of super plasticizer were constant. Proportions of trial mixes were carried out using the absolute volume method. Each concrete mix was tested to achieve workability property then specimens of size 150mmx150mmx150mm cubes were casted for conducting compressive strength tests. Finally suitable concrete mix was selected based on the workability property in its fresh state, compressive strength and durability requirements.

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Data's are obtained from experimental program

- Packing factor (PF)= 1.04
- Specific gravity of Cement (G_c) = 3.12
- Specific gravity of FA (G_{fa}) = 2.61
- Specific gravity of CA (G_{ca}) = 2.68
- Specific gravity of Fly ash (G_f) = 2.1
- Specific gravity of water (G_w) = 1.0
- Bulk density of FA (W_{fa}) = 1594 Kg / m3
- Bulk density of CA (W_{ca}) = 1264 Kg / m3
- The volume ratio of fine to total aggregate = 0.54
- Super Plasticizer (SP) dosage = 0.8%
- Air content (Va) = 1.5 %

IV. RESULTS AND DISCUSSION

The Workability test results with recommended limits of different Nan-Su coefficients 7, 8, 9, 10, and 11 are tabulated in table 2 and compressive strength results corresponds to M35 grade of SCC for all Nan-Su coefficient are tabulated in table 3.

Nan-Su Coefficient	W/C ratio	SP in (%)	Slump flow (mm)	V-funnel flow (sec)	U-Box test Results(mm)	L-box Ratio (h2/h)
7	0.34	0.8	699	11	22	0.89
8	0.38	0.8	695	12	26	0.84
9	0.41	0.8	710	10	24	0.83
10	0.44	0.8	725	09	28	0.83
11	0.47	0.8	735	11	25	0.86
Recommended limits		**_**	**650 – 800 mm**	**8 – 12 sec**	**0-30 mm**	**0.8 – 1**

Table 2. workabity test results for Nan –su coefficients

Table 3: compressive strength test results

Nan-Su coefficients	7	8	9	10	11
7-days compressive strength (MPa)	10.51	18.51	22.07	36.58	40.13
28-days compressive strength (MPa)	21.92	26.96	34.6	44.58	47.76

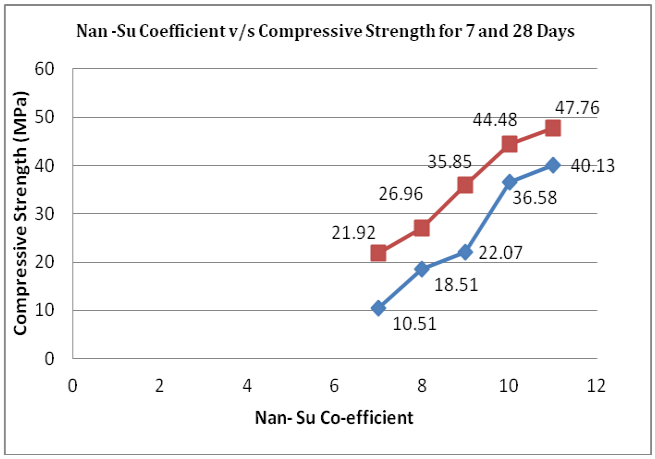

Fig 2: Graph between Nan-Su coefficient verses compressive strength

By seeing above fig 2 it's easy to access that 28-days compressive strength of cubes is greater compare to 7-days compressive strength of cubes and also both 7 and 28-days compressive strength goes on increases as the Nan-Su coefficient goes on increasing because the content of cement required for m35 of concrete enhances.

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Recommended Mix Design for M35 Grade SCC

According to IS 10262-2009 code the target strength for M35 concrete is 43.25 Mpa. In this experimental work the results of Nan su coefficient 10 at W/C =0.44 is comply withM35 concrete mix, which is tabulated in the table 4 and 5

Table 4: The concrete mix proportions for coefficient 10

CEMENT (Kg)	F.A(Kg/m^3)	C.A (Kg/m^3)	FLY ASH (Kg/m^3)	WATER (Lit)	S.P (Kg/m^3)
350	895.19	604.70	165.75	225.27	4.13
1	2.56	1.73	0.47	0.64	0.014

Table 5: Recommended Mix Design test results for M30 grade SCC.

Nan Su coefficient		10
Water cement ratio		0.44
Super plasticizer dosage (%)		0.80
Quantity of concrete per m3	Cement (kg)	350
	Fine aggregate (kg)	895.19
	Coarse aggregate (kg)	604.70
	Fly ash (kg)	165.75
	Water (lit)	225.27
	Super plasticizer (kg)	4.13
7-days compressive strength (MPa)		36.58
28-days compressive strength (MPa)		44.48
Workability test results	Slump value (mm)	725
	V-funnel value (sec)	9
	L-box ratio	0.83
	U-box test value (mm)	28

V. CONCLUSIONS

a) In this dissertation study cubes were casted for Nan-Su coefficient 7,8,9,10,11 for M35 grade SCC and achieved expected results for 7-days & 28-days compressive0strength for Nan-Su coefficient 7,8,9,10,and11. Finally got the required strength of about 43.25 MPa for M35 grade of self-compacting concrete for Nan-Su coefficient 10, with w/c ratio 0.44 and super plasticizer dosage0.8.

b) on the basis of results obtained conclusions are

- As the Nan –su coefficient increases, the water cement ratio also increased to satisfy all the requirements of SCC.
- As the Nan-Su's co-efficient increases, the water cement ratio gets increases, thus the flow ability of the concrete also increases. This we can observe in the test results of slump flow.
- As the Nan su coefficient increases, the quantity of cement per m^3 gets increased.
- From this work we can conclude that Nan –su method of mix design is also applicable for lower grade of SCC.

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