# EXPERIMENTAL STUDIES ON M20 SELF COMPACTING CONCRETE

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## ABSTRACT

*In the present investigation a simple mix design procedure proposed by Nan Su was used by changing the Nan-Su's coefficient for calculating the cement content i.e. C=7f*¹c *and water cement ratio to achieve M20 grade SCC. In the present work a wide range of SCC mix were developed using fly ash as a filler material along with Portland cement of 43 grade. To qualify Self-Compacting Concrete mixes Slump flow, V-funnel, L-Box, U-Box tests were conducted and the fresh properties obtained are checked against the specifications given by EFNARC guidelines. Compressive strength tests were conducted to know the strength properties of the mixes at the age of 7 and 28 days of curing. It has been observed that for Nan- Su's coefficient 11 i.e. C=11f*¹c *the M20 grade SCC is achieved by satisfying all the requirements given by EFNARC guidelines.*

***Keywords* — Nan-*Su's Coefficient For Calculating The Cement Content, Water Cement Ratio, Fly Ash, Compressive Strength, SCC***

## I. INTRODUCTION

Self compacting concrete is a concrete which can be placed and compacted under its own weight with little or no vibration effort. SCC is the modified concrete with the use of chemical and mineral admixtures in the concrete. It is designed generally with high content of powder/fine material. To facilitate flow and penetration through congested reinforcement zones, it is desirable to avoid 20mm aggregate. If more coarse aggregate is used, flow rate will be diminished due to frictional loss and stresses.

SCC is still not widely used in India in spite of its many advantages including reduction in labour and fast track construction etc. This is because of lack of sufficient data and information on SCC made of materials available in the different parts of the country and hence insufficient confidence of engineers in producing this materials**.** India has abundant supply of flyash, with its sources well distributed across the country. SCC generally possesses a high powder content which keeps the concrete cohesive with high flowability. This high powder content is required to maintain a sufficient yield value of the fresh mix and cement cannot be the only powder material in SCC. For achieving economy, a substantial part of this powder could also contain flyash. SCC can accommodate more than 200 $kg/m^3$ of fly ash which is regarded as a high volume addition. Hence it is considered worthwhile to investigate the influence of flyash in SCC.

An extremely important aspect of the durability of concrete is its permeability. Fly ash concrete is less permeable because fly ash reduces the amount of water needed to produce a given slump, and through pozzolanic activity, creates more durable CSH (calcium-silicate-hydrate) as it fills capillaries and bleeds water channels occupied by water-soluble lime (calcium hydroxide). Fly ash improves corrosion protection. By decreasing concrete permeability, fly ash can reduce the rate of ingress of water, corrosive chemicals and oxygen- thus protecting steel reinforcement from corrosion and its subsequent expansive result. Fly ash also increase sulfate resistance and reduces alkali-silica reactivity. At this point a distinction between Class C and F fly ashes needs to be made. While both improve the permeability and general durability of concrete, the chemistry of Class has proven to be more effective in mitigating sulfate and alkali-silica expansion and deterioration in concrete. Some Class C fly ashes have been used to mitigate these reactions, but must be used at higher rates of cement replacement. Fly ash has been shown to be an effective addition for SCC providing increased cohesion and reduced sensitivity to changes in water content. However, high levels of fly ash may produce a paste fraction which is so cohesive that it can be resistant to flow.

### Requirements for SCC

SCC exhibits following properties in its plastic state.

- **Filling Ability:** It is the ability of SCC to flow into and fill completely all spaces in the formwork and encapsulate reinforcement while maintaining homogeneity.
- **Passing Ability:** It is the ability of concrete mix to pass through obstacles like narrow sections in form work, closely spaced reinforcement bars without getting blocked by interlocking of aggregate particles.
- **Resistance to segregation:** Segregation resistance of self compacting concrete is its capability to retain homogeneity in the distribution of ingredient in fresh state during both static and moving condition i.e., during mixing , transportation and placing. It is dependent on viscosity of mix in fresh state.

## II. MATERIALS AND METHODOLOGY

*Cement* -Cement is such a material that has cohesive and adhesive properties in the presence of water such cement is called hydraulic cement. These consist preliminary of silicates and aluminates of lime obtained from limestone and clay. In this experiment 43 grade ordinary Portland cement (OPC) with brand name Ultra tech was used for all SCC mixes. The cement used was fresh and without any lumps, the testing of cement was done as per IS: 8112-1989.

*Fine Aggregates* - The sand used in this present study is collected from the bed of river Tungabhadra The sand passing through 4.75 mm size sieve is used in the preparation of concrete mix. The sand confirms to grading Zone II as per IS: 383-1970 (Reaffirmed 1997). The properties of sand such as fineness modulus and specific gravity were determined as per IS: 2386-1963. The specific gravity of fine aggregate is found to be 2.64 and having fineness modulus 2.62. The water absorption is 1.5%. The bulk density of fine aggregate in compact state 1768 $kg/m^3$.

*Coarse aggregate*: The coarse aggregate used in this present study is 12.5 mm down size graded confirm to IS 383-1970 (Reaffirmed 1997) locally available crushed stone obtained from local quarries. The physical properties have been determined. The specific gravity of coarse aggregate is found to be 2.65. The water absorption is 0.3%. The bulk density of coarse aggregate in compact state is 1584$kg/m^3$.

*Water* -The water used in the mixing of concrete was potable water and its free from organic content , turbidity and salts confirms to IS 456-2000 was used for mixing and for curing throughout the experiment program.

*Filler ( Flyash)*- Filler Materials such as flyash, blast furnace slag, etc. are commonly used as filler for producing SCC. An extremely important aspect of the durability of concrete is its permeability. Fly ash concrete is less permeable because fly ash reduces the amount of water needed to produce a given slump, and through pozzolanic activity, creates more durable CSH as it fills capillaries and bleed water channels occupied by water-soluble lime Fly ash improves corrosion protection. By decreasing concrete permeability, fly ash can reduce corrosive chemicals and oxygen- thus protecting steel reinforcement from corrosion and its subsequent expansive results.Fly ash also increase sulfate resistance and reduces alkali-silica reactivity in this research Flyash is used as a filler material. Fly ash from Raichur thermal power station, Karnataka was used.

*Super plasticizer***-** As the locally available PCE based super plasticizers proved to be very effective in SCC, this study is carried out using such type of super plasticizers .AUROMIX 400 Commercially available poly-carboxylic ether based super plasticizer It is an admixture of a new generation based on modified polycarboxylic ether. AUROMIX 400 is a super plasticizer manufactured by FOSROC CONSTRUCTIVE SOLUTIONS, was used in this experimentation. Its use emhances the workability of the mix and strength aspect, helps in producing a better compaction and finishing. It also permits reduction in water content

## EXPERIMENTAL WORK

### Design mix for SCC by Nan Su method [8]

Details of selecting a suitable SCC mix for evaluating its performance in terms of strength and durability are described. For selecting a suitable mix using local aggregates, the trail mixes with different Nan-Su coefficients for calculating cement content 7,8,9,10,11 and 12 are conducted by varying the Water-cement ratios, and remaining parameters like quantity of fine aggregate and coarse aggregate were constant. Proportioning of the trial mixes was carried out using the absolute volume method. Each mix was tested for self compatibility and compressive strength. Finally, a suitable mix was selected based on the self-compatibility and strength test results.

### Data's are obtained from experimental program

- Packing factor (PF)= 1.07
- Sp gravity of Cement ($G_c$) = 3.1
- Sp gravity of FA ($G_s$) = 2.64
- Sp gravity of CA ($G_g$) = 2.65
- Sp gravity of Flyash ($G_f$) = 2.1
- Sp gravity of water ($G_w$) = 1.0
- Bulk density of FA ($W_{sl}$) = 1768 Kg / $m^3$
- Bulk density of CA ($W_{gl}$) = 1584 Kg / $m^3$
- Max size of aggregate = 10 mm

- The volume ratio of fine / coarse aggregate = 58 / 42
- Super Plasticizer (SP) = AUROMIX 400 (FOSROC CONSTRUCTIVE SOLUTIONS)
- Air content (Va) = 2 %
- Designed compressive strength (psi) f'c = 20 MPa

**Mix Proporations**:

Cement: Fine Aggregate: Coarse Aggregate: Fly ash: Water: SP

220: 972: 713: 154: 199.1: 3.179

1: 4.41: 3.24: 0.7: 0.905

In this study SCC specimens were casted for compressive strength test of cube size 150mm x150mmx150mm. Which consist of Cement, sand, aggregate, filler (Fly Ash), super plasticizer were taken in mix proportion 1: 4.41: 3.24: 0.7: 0.905 which correspond to M20 grade of concrete. The ingredients of concrete were thoroughly mixed in concrete mixer machine. Before casting oil was smeared to the inner surface of the moulds. Concrete was poured in to the moulds without any hand compaction and vibration. The specimens were given finished smooth with trowel. After 24 hours, the specimens were demoulded and transferred to curing tanks where they were allowed to cure for 7 and 28 days. Then they were tested for compressive strength.

## III. EXPERIMENTAL RESULTS

The Workability test results with recommended limits of different Nan-Su coefficients 7,8,9,10,11 and 12 are tabulated in table 1 and compressive strength corresponds to $M_{20}$ grade of SCC for Nan-Su coefficient 11 is tabulated in table 2.

**TABLE 1**

**Workability test results with recommended limits**

| Nan-Su Coefficient | W/C ratio | SP in % | Slump flow(mm) | V-funnel flow (sec) | U-Box test Results(mm) | L-box Ratio (h2/h1) |
|---|---|---|---|---|---|---|
| 7 | 0.4 | 0.85 | 708 | 9 | 24 | 0.9 |
| 8 | 0.45 | 0.85 | 718 | 10 | 18 | 0.86 |
| 9 | 0.5 | 0.85 | 726 | 8 | 20 | 0.94 |
| 10 | 0.54 | 0.85 | 731 | 9 | 21 | 0.92 |
| 11 | 0.59 | 0.85 | 739 | 11 | 19 | 0.89 |
| 12 | 0.64 | 0.85 | 742 | 9 | 20 | 0.91 |
| **Recommended limits** | | – | **600 – 800 mm** | **8 – 12 sec** | **0-30 mm** | **0.8 – 1** |

**TABLE 2**

**Compressive strength of M20 grade SCC for coefficient 11 with W/C ratio 0.59**

| Nan-Su's coefficient | Age in days | Weight in kg | load in KN | compressive strength in ($N/mm^2$) | Avg. compressive strength ($N/mm^2$) |
|---|---|---|---|---|---|
| 11 | 7 | 8.0 | 400 | 17.78 | 18.23 |
| | | 7.9 | 420 | 18.22 | |
| | | 8.1 | 410 | 18.22 | |
| | 28 | 8.2 | 660 | 29.33 | 29.33 |
| | | 8.0 | 640 | 28.44 | |
| | | 8.2 | 680 | 30.22 | |

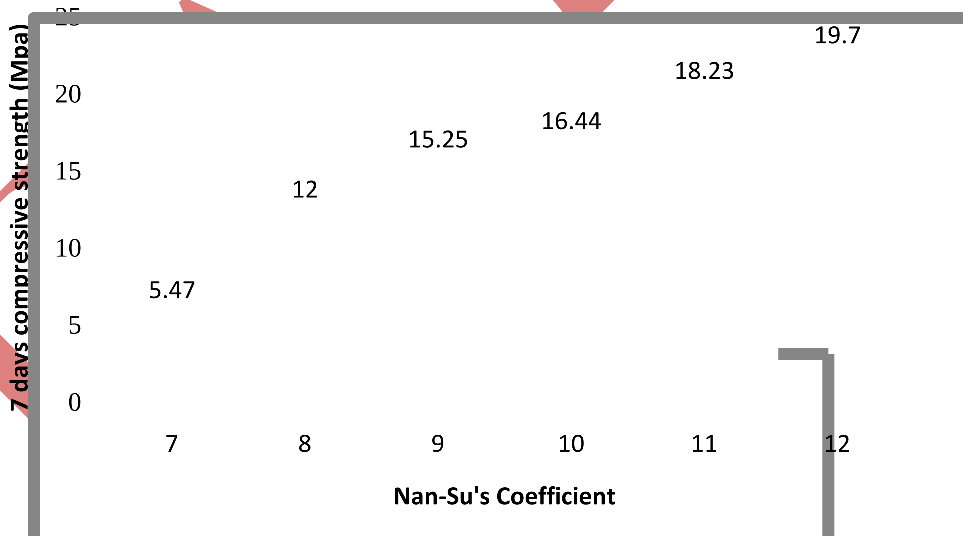


**Figure 1: showing Comparison between Nan-Su's Coefficients versus 7 days compressive strength**

From fig 1 it is observed that as Nan-Su's Coefficient increases, 7 days compressive strength also get increased since the cement content per $m^3$ get increased

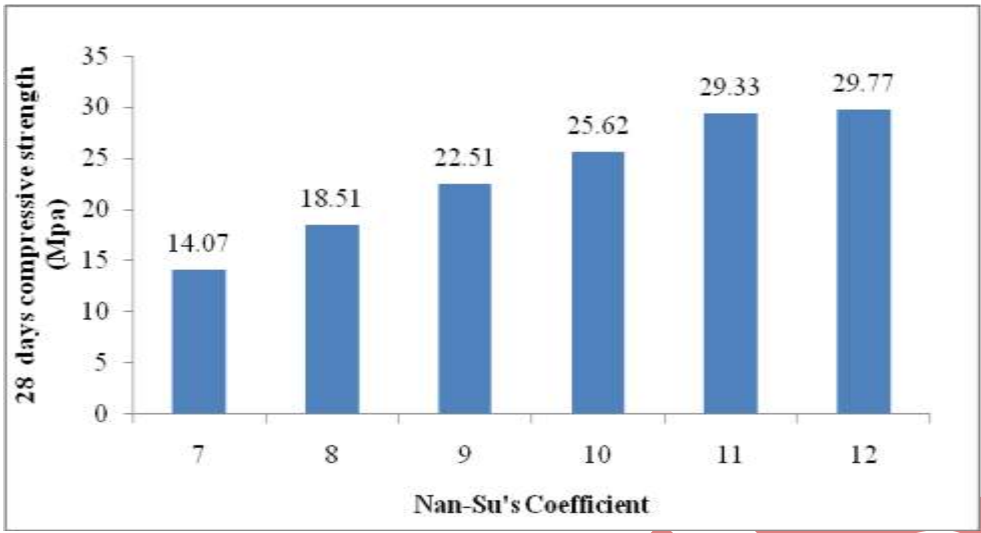


**Figure 2: showing Comparison between Nan-Su's Coefficients versus 28 days compressive strength**

From fig 2 it is observed that as Nan-Su's Coefficient increases, 28days compressive strength also get increased since the cement content per $m^3$ get increased.

## Recommended Design Mix

According to IS 10262-2009 code the target strength for M20 concrete is 26.6 Mpa. In this experimental work the results of Nan-Su's coeffeceint 11 is comply with M20 concrete mix.Which is tabulated in table 3

**TABLE 3**

**Recommended Design Mix test results**

| Nan-Su Coefficient | W/C ratio | SP in % | Slump flow(mm) | V-funnel flow | U-Box test | L-box Ratio (h2/h1) | 7 Days Avg. compressive strength ($N/mm^2$) | 28 Days Avg. compressive strength ($N/mm^2$) |
|---|---|---|---|---|---|---|---|---|
| 11 | 0.59 | 0.85 | 739 | 11 | 19 | 0.89 | 18.23 | 29.33 |
| **Recommended limits** | | – | **600 – 800 mm** | **8 – 12 sec** | **0-30 mm** | **0.8 – 1** | | |

## IV. CONCLUSIONS

On the basis of results the following conclusions can be drawn.

1. As Nan-Su's co-efficient increases, the water cement ratio also get increased to satisfy the requirements of SCC.
2. As the water cement ratio increases, the flow ability of the concrete also increased. This we can observe in the test results of slump flow.
3. As the Nan-Su's co-efficient increases, the quantity of cement per $m^3$ get increased hence, strength also get increased.
4. As the Nan-Su's co-efficient increases, the quantity of filler material per $m^3$ get decreased. Since the filler material do not participate in the strength parameter, as the filler material decreased, strength get increased.
5. In case of all the Nan-Su's co-efficient, the quantity of fine and coarse aggregate remains same since these are independent of Nan-Su's co-efficient and water cement ratio.
6. From this work we can conclude that Nan-Su's method of mix design is also applicable for lower grade of SCC.
7. SCC designed and produced with the proposed mix design method contains more sand but less coarse aggregates, thus the passing ability through gaps of reinforcement can be enhanced.

## AKNOWLEDGEMENT

The authors wish to thank the authorities of Visvesvaraya Technological University, Belgaum for giving an opportunity to conduct the experiments in the Concrete and Highway Engineering Laboratory of University BDT College of Engineering Davangere. 577004.

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