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# COMPARISION OF IS CODE METHOD AND NAN-SU METHOD OF MIX DESIGN FOR SCC

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***Abstract:*** ***Self Compacting Concrete is a highly fluid concrete mixture with no segregation and can compact under its own weight. Looking at the potential of cementitious constituents in fly ash, it can be used as partial replacement of cement in SCC to achieve self compaction. Reused Aggregate is called as Recycled Coarse Aggregate (RCA) which is mainly obtained from demolished concrete structures. RCA in Unprocessed and Processed state (500R & 1000R) used as a partial replacement of Natural Coarse Aggregate (NCA) with varying percentages (0%, 25%, 50%, 75% and 100%). In this experimental investigation, the standard grade of SCC mixes were designed using IS code method and Nan-Su method. The fresh properties of SCC has been determined using Slump cone, V-Box, L-Box, were compared for the assessment of the Self-Compactability of concrete for both methods. A number of trial mixes were made using IS code method and Nan-su method: by changing sizes of coarse aggregate; varying percentages of Flyash; varying the dosages of Super Plasticizer(SP). It was found that the final mix proportion using Nan-su method shows satisfying results in terms of fresh properties of SCC compared to IS code method i.e., at 50% partial replacement of NCA with processed(500R) RCA.***

***Keywords: Nan-Su method, Self-Compacting Concrete (SCC), NCA, RCA, SP***

## I. INTRODUCTION

Self Compacting Concrete is a highly fluid concrete mixture with no segregation and can compact under its own weight without any vibration. Fine particles play important role in SCC, making its flowable characteristics improve and to maintain adequate yield value of fresh mix. Mineral admixtures like flyash could increase the slump value of the concrete and used as a partial replacement of cement. Required dosage of superplasticizer is considered to maintain the slump flow of the concrete.

Reused Aggregate is called as Recycled Coarse Aggregate which is mainly obtained from demolished concrete structures is in unprocessed state. The RCA has cement paste adhered to its surface and characterized as a type of concrete aggregates with higher porosity, higher water absorption, lower density as well as lower mechanical strength compared to NCA. RCA is processed using Deval's abrasion test for different number of revolutions like 500, 1000 Revolutions.

Nan-Su method of mix design is employed to obtain mix-proportion for SCC and suitable mix for M35 grade of concrete was finalised after a number of trial mixes. Nan-Su method uses Flyash and super-plasticizer for mix design. In this study Class-F Flyash and Super Plasticizer Conplast-SP 430 have been used to achieve SCC. The fresh properties of SCC with all constituents including RCA in Unprocessed and Processed state (500R & 1000R) as a partial replacement of Natural Coarse Aggregate (NCA) in different percentages (0%, 25%, 50%, 75% & 100%) has been determined viz, passing ability, filling ability and segregation resistance, for the assessment of the Self-Compactability of concrete.

## II. MATERIALS

### *A. Cement*

In this experiment, Birla A1 cement of 53 grade ordinary Portland cement (OPC) is used for all concrete mixes. The cement is of uniform colour without any lumps. The properties of Ordinary Portland cement were found by conducting tests based on standard IS codes and represented in the table below:

TABLE I
Properties of Cement

| Tests | Results |
|---|---|
| Standard Consistency | 33% |
| Fineness | 5% |
| Specific Gravity | 3.15 |
| Initial Setting Time | 150 minutes |
| Final Setting Time | 220 minutes |

### *B. Flyash*

In this experiment, fly ash is procured from Kakatiya thermal power station(KTPS), Bhupalpally, Telangana.

TABLE II
Properties of Flyash

| Tests | Results |
|---|---|
| Specific Gravity | 2.25 |
| Class | F |

### *C. Fine Aggregate*

The sand used for this project was locally procured and conformed to grading zone II as per IS 383-1970.

TABLE III
Properties of Fine Aggregate

| Tests | Results |
|---|---|
| Specific Gravity | 2.6 |
| Bulk Density | 1500Kg/m$^3$ |
| Grading Zone | II |
| Fineness modulus | 2.6 |
| % of Voids | 35% |
| Void Ratio | 0.52 |

### *D.* Natural Coarse Aggregate

Locally available coarse aggregate having the maximum size of 16mm and minimum size of 12mm were used in the present work.

TABLE IV
Properties of Coarse Aggregate

| Tests | Results |
|---|---|
| Specific Gravity | 2.77 |
| Bulk Density | 1402Kg/m$^3$ |
| Void Ratio | 0.8 |
| % of Voids | 48.6% |
| Fineness Modulus | 7.89 |

*E. Recycled Coarse Aggregate*

Recycled Coarse Aggregate of 16mm and minimum of 12mm size.

TABLE V
Properties of Recycled Coarse Aggregate

| Tests | Results |
|---|---|
| Specific Gravity | 2.84 |
| Bulk Density | 1404Kg/$m^3$ |
| % Of Voids | 44.6% |
| Void Ratio | 0.82 |

## III. Mix Design

Nan-Su method of mix design is a process of finding the suitable mix proportions for concrete mix which includes cement, fine aggregate, coarse aggregate, chemical admixtures & mineral admixtures to achieve self compactability.

| Data: | | DESCRIPTION |
|---|---|---|
| PF | 1.1 | PF -Packing Factor |
| $W_{gL}$ | 1404 Kg/m3 | Bulk density of loosely piled SSD coarse aggregates in air |
| $W_{sL}$ | 1500 Kg/m3 | Bulk density of loosely piled SSD fine aggregates in air |
| $S_a$ | 56% | $S_a$ = (FA/TA) |
| $f'_{ck}$ | 35 Mpa<br>44.9 Mpa | **NOTE: 'S' Value taken from Table-8,Pg. No:23,IS 456:2000** |
| | 6512.2062 Psi | Target mean strength |
| W/C | 0.38 | water to cement ratio |
| W/F | 0.38 | Water to flyash ratio |
| $SG_{CA}$ | 2.84 | Sp. Gravity of RCA |
| $SG_{FA}$ | 2.6 | Sp. Gravity of FA |
| $SG_C$ | 3.15 | Sp. Gravity of Cement |
| $SG_W$ | 1 | Sp. Gravity of Water |
| $SG_F$ | 2.25 | Sp. Gravity of Mineral Admixture |
| $a_{sc}$ | 1.50% | Air content in SCC |

**STEP-1:** **Calculation of CA &FA content**

$C_{CA}$ 679.54 Kg/$m^3$ $C_{CA} = PF \times W_{gL} \times (1-S_a)$

$C_{FA}$ 924 Kg/$m^3$ $C_{FA} = PF \times W_{sL} \times S_a$

**STEP-2:** **Calculation of Cement content**

$C_c$ 325.61 Kg/$m^3$ $C_c = f'_{ck}/20$

**Water content**

$W_{wc}$ 123.73 lt/$m^3$ $W_{wc} = (w/c) \times C_c$

**STEP-3:** **Determination of Flyash content**

$V_F$ 0.163 Kg/$m^3$ $V_{MA} = 1-(C_{CA}/1000 \times SG_{CA})-(C_{FA}/1000 \times SG_{FA})-(C_C/1000 \times SG_C)-(W_{WC}/1000 \times SG_W)-1.5\%$

$C_F$ 198 Kg/$m^3$ $V_{MA} = (C_F/(SG_F*1000))+((W/F)*C_F)/(1000))$

**Water content**

$W_{WF}$ 75.24 lt/$m^3$ $W_{WF} = (W/F) \times C_F$

**STEP-4:** **Determination of Chemical admixture or SP used content**

| | | |
|---|---|---|
| X% | 1.20% | |
| Y% | 40.00% | |
| HRWR | 6.28 lt/m$^3$ | HRWR = $X\%(C_C + C_{MA})$ |

**Reducing Water content**

| | | |
|---|---|---|
| $W_{WSP}$ | 3.77 lt/m$^3$ | $W_{WSP} = (1-Y\%)SP$ |

**STEP-5:** **Determination of Total water content**

| | | |
|---|---|---|
| $C_{TW}$ | 195.2 lt/m$^3$ | $C_{TW} = W_{WC} + W_{WF} - W_{WSP}$ |

TABLE VI

Mix Design of M35 Grade Concrete

| Materials | Cementitious | Fine aggregate | Coarse aggregate | Water (lit.) |
|---|---|---|---|---|
| **Quantity (kg/m$^3$)** | 523.61 | 924 | 680 | 195.20 |
| **Proportions** | 1 | 1.76 | 1.30 | 0.38 |

## IV. EXPERIMENTAL PROGRAM

In this experiment trial mixes were done using IS Code method and Nan-Su method of mix design and compared to achieve suitable method for self compactability of concrete mix satisfying the EFNARC specifications.

Trial mix-1:
Mix design using IS 10262:2009 for SCC with mix proportion (1 : 1.39 : 2.66).

| | | |
|---|---|---|
| Cement | = | 349 Kg/m$^3$ |
| Flyash | = | 116 Kg/m$^3$ |
| Water | = | 148 Kg/m$^3$ |
| Fine Aggregate | = | 648 Kg/m$^3$ |
| Coarse Aggregate | = | 1239.6 Kg/m$^3$ |
| Chemical Admixtures | = | 5 Kg/m$^3$ |

Trial mix-2:
Mix design using Nan-Su method with mix proportion (1 : 1.88 :1.70).

| | | |
|---|---|---|
| Cement | = | 313.64 Kg/m$^3$ |
| Flyash | = | 140 Kg/m$^3$ |
| Water | = | 200.94 Kg/m$^3$ |
| Fine Aggregate | = | 852.5 Kg/m$^3$ |
| Coarse Aggregate | = | 770 Kg/m$^3$ |
| Chemical Admixtures | = | 5.45 Kg/m$^3$ |

Trial mix-3:
Mix design using Nan-Su method with mix proportion (1 : 1.76 : 1.30).

| | | |
|---|---|---|
| Cement | = | 325.61 Kg/m$^3$ |
| Flyash | = | 198 Kg/m$^3$ |
| Water | = | 195.2 Kg/m$^3$ |
| Fine Aggregate | = | 924 Kg/m$^3$ |
| Coarse Aggregate | = | 680 Kg/m$^3$ |
| Chemical Admixtures | = | 6.28 Kg/m$^3$ |

# V. RESULTS

The preliminary tests were conducted for all trial mixes and trial mix-3 has satisfied flowable characteristics of SCC and all the preliminary test results of trial mix-3 were shown below:

## A. *Fresh properties of SCC*

Fig. 1: Slump flow test equipment.

Fig. 2: Slump flow at $T_{50}$ sec for 50% RCA 500R

TABLE VII
Slump flow test results

| % of RCA | Unprocessed | | Processed(500R) | | Processed (1000R) | |
|---|---|---|---|---|---|---|
| | $T_{50}$ (sec) | Slump Diameter | $T_{50}$ (sec) | Slump Diameter | $T_{50}$ (sec) | Slump Diameter |
| 0% | 5 | 580 | - | - | - | - |
| 25% | 5 | 600 | 4 | 700 | 4 | 680 |
| 50% | 2 | 610 | 3 | 680 | 3 | 655 |
| 75% | 4 | 600 | 2 | 720 | 3 | 705 |
| 100% | 3 | 630 | 3 | 690 | 2 | 720 |


Fig. 3: V-Funnel test equipment.

TABLE VIII
V-Funnel test results

| % of RCA | Unprocessed | Processed(500R) | Processed (1000R) |
|---|---|---|---|
| | $T_{5min}$ | $T_{5min}$ | $T_{5min}$ |
| 0% | 18 | - | - |
| 25% | 20 | 19 | 19 |
| 50% | 18 | 18 | 18 |
| 75% | 15 | 15 | 15 |
| 100% | 10 | 11 | 11 |

Fig. 4: L-Box test apparatus.

TABLE IX

L-box test results

| % of RCA | Unprocessed | Processed(500R) | Processed (1000R) |
|---|---|---|---|
| | Blocking Ratio($H_2/H_1$) | Blocking Ratio($H_2/H_1$) | Blocking Ratio($H_2/H_1$) |
| 0% | 0.71 | - | - |
| 25% | 0.71 | 0.75 | 0.76 |
| 50% | 0.72 | 0.73 | 0.72 |
| 75% | 0.70 | 0.74 | 0.74 |
| 100% | 0.70 | 0.69 | 0.68 |

## VI. CONCLUSIONS

1. IS Code method i.e., trial mix-1 is unable to achieve the properties of SCC because the Particle Packing Factor (PPF) is not considered in this method of mix design.
2. PPF plays an important role in mix design of SCC, which increases the density of concrete by increasing the finer particles in mix. These finer particles help in filling all voids present in concrete and also helps in increasing the flowability of concrete to achieve slump value.
3. Mix proportion of trial mix-2 designed using Nan-Su method also has not satisfied flowable characteristics of SCC, since it has considered single size of coarse aggregates and not suitable water to cement ratio.
4. Mix proportion of trial mix-3 designed using Nan-Su method by considering suitable w/c ratio has satisfied flowability characteristic feature of the concrete mix.
5. All the fresh properties of SCC for trial mix-3 such as Slump value, V-Funnel, L-Box test are shown above.
6. It is mainly achieved by considering suitable PPF while two different sizes of coarse aggregates and required dosage of chemical admixture were also chosen to achieve required flowability.
7. Thus Nan-Su method is the best suitable method of mix design for Self Compacting Concrete than IS Code method.
8. In this experiment, CA used is a recycled aggregate, all the fresh properties of SCC has achieved up to the mark at 50% partial replacement of NCA with processed(500R) RCA.

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