# Study on Properties of Self Compacting Concrete Made with Recycled Coarse Aggregate

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**Abstract -** *Self Compacting Concrete is a flowing concrete mixture that is able to consolidate under its own weight.. Use of SCC can also help in minimize hearing damage on the work site that is induced by vibration of concrete. The use of recycled concrete aggregates from demolition waste and rubble in combination with cementitious additions in concrete has several advantages. In this paper experimental studies are carried out to understand the fresh and hardened properties of SCC in which natural coarse aggregate is replaced by recycled coarse aggregate at 15%, 30% and 45%. The cement content was also partially replaced by Ground Granulated Blast Furnace Slag and Fly Ash. The mix design was carried out for M30 grade of concrete. The fresh properties of SCC were determined . The strength behaviour, flexural behavior, split tensile strength ,modulus of elasticity and shear strength behaviour of SCC are studied. The compressive strength, flexural strength and split tensile strength was measured at the ages of 7, 28, and 56 days. The mechanical properties were reduced with the incorporation of recycled coarse aggregate due to the poor adhesion between the mortar and aggregate. The results indicate that compressive strength, flexural strength, split tensile strength Modulus of Elasticity , and shear strength of SCC decreases with increase in the amount of RCA. The present study recommends SCC marginally achieves required compressive strength up to 30% replacement of RCA.*

***Key Words*: SCC, Recycled coarse aggregate ,GGBFS, Fly ash ,Compressive strength, Split tensile strength and Flexural strength, Modulus of Elasticity, Shear strength**

## 1. INTRODUCTION

Making concrete structures without vibration, have been done in the past. For examples, placement of concrete under water is done by the use of tremie without vibration. Mass concrete, and shaft concrete can be successfully placed without vibration, but the above examples of concrete are generally of lower strength and difficult to obtain consistent quality. Modern application of self compacting concrete is focussed on high performance, better and more reliable and uniform quality.

Self compacting concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement .The hardened concrete is dense, homogenous and has the same engineering properties and durability as traditional vibrated concrete.SCC offers a rapid rate of concrete placement ,with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. The elimination of vibrating equipment improves the environment on and near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration.

Recycled aggregates have the added benefit of reducing landfill disposal, while conserving primary natural resources and reducing transportation costs, help to promote sustainable development in the protection of natural resources.

## 2. MATERIALS

### 2.1Cement

Ordinary Portland Cement (53 grade) confirming to IS:12269-1987 was used for all the concrete mixtures. The tests were conducted according to IS 4031-1988.The physical properties are given in Table 1

**Table -1:** Physical properties of cement

| Properties | Test Results |
|---|---|
| Specific gravity | 3.12 |
| Standard Consistency(%) | 33 |
| Initial setting time(minutes) | 86 |
| Final setting time(minutes) | 285 |

### 2.2Aggregates

The maximum size of coarse aggregate and recycled coarse aggregate used in the concrete mixture is 12.5 mm. Natural fine aggregate used is Manufactured sand

**Table -2:** Physical properties of Aggregates

| **Type of aggregate** | Water absorption | Specific gravity |
|---|---|---|
| Coarse Aggregate | 0.64% | 2.74 |
| Recycled coarse aggregate | 0.79% | 2.53 |
| Fine aggregate | 1.4% | 2.67 |

### 2.3 Fly Ash

Fly ash is a fine inorganic material with pozzolanic properties, which can be added to SCC to improve its properties .Class F fly ash is used for the project Specific gravity is 2.7.

### 2.4 Ground Granulated Blast Furnace Slag

GGBFS is bought from Astrra chemicals Pvt.Ltd, Chennai. Specific gravity is 2.85.

### 2.5 Water

Portable water which is available at the laboratory premises was used for mixing of concrete ingredients. Water from sources like industrial plants, sewage and other contaminated should not used for concrete making.

## 3. MIX DESIGN

For the present work SCC of grade M30 was adopted. In this study the mix design procedure suggested by modified Nan – su et al was used, which satisfy the requirements of EFNARC guidelines. The Mix proportion was obtained as 1: 2.14 : 1.90 : 0.57 : 0.32 : 0.33 .The mix notation is shown in table 3.

**Table -3:** Mix notations

| | |
|---|---|
| RA0 | M30 Self Compacting Concrete |
| RA15 | M30-SCC with 15% replacement of coarse aggregate with recycled coarse aggregate |
| RA30 | M30-SCC with 30% replacement of coarse aggregate with recycled coarse aggregate |
| RA45 | M30-SCC with 45% replacement of coarse aggregate with recycled coarse aggregate |

## 4. EXPERIMENTAL PROGRAMME

### 4.1 Test on Fresh Concrete

The flowability, viscosity and passing ability of fresh SCC were determined by slump flow test, V- funnel test and L-box test respectively.

### 4.2 Prepartion of Test Specimen

Concrete cubes of 150×150×150mm were casted for compressive strength. For flexural strength beam of size 100×100×500mm were used. For split tensile strength and modulus of elasticity cylinder of size 300×150mm were used.

### 4.3 Test on Hardened Concrete

The concrete were tested for the hardened properties like compressive strength, flexural strengths split tensile ,modulus of elasticity and shear strength each for 7 days, 28 days and 56 days .

## 5. EXPERIMENTAL RESULTS

### 5.1 Fresh Concrete

Fresh properties of different mix were tabulated in table 3

**Table -4:** Fresh properties of concrete

| Test | RA0 | RA15 | RA30 | RA45 |
|---|---|---|---|---|
| Slump-flow | 675 | 650 | 595 | 575 |
| $T_{500}$ | 3.7 | 4.1 | 4.2 | 4.6 |
| V-funnel | 10.1 | 10.2 | 10.4 | 10.6 |
| L-box | 1.1 | 0.96 | 0.92 | 0.84 |

### 5.2 Hardened Concrete

#### 5.2.1 Compressive Strength

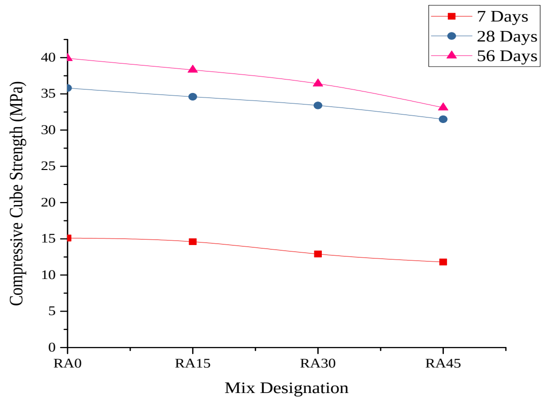


**Chart-1:** Compressive Cube Strength Results Vs Mix Designation

The incorporation of recycled coarse aggregate in the concrete causes a decrease in the compressive strength at all the mixes mainly due to the poor adhesion between the old mortar and aggregate. As percentage of RCA increases, the compressive strength of SCC decreases. However, as expected compressive strength has been found to increase with increase in the curing period.

#### 5.2.2 Flexural Strength

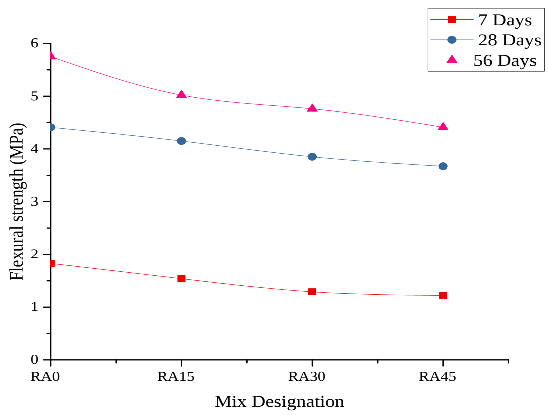


**Chart-2:** Flexural Strength Results Vs Mix Designation

As percentage of RCA increases, the flexural strength of SCC decreases. However, as expected flexural strength has been found to increase with increase in the curing period.

### 5.2.3 Split Tensile Strength

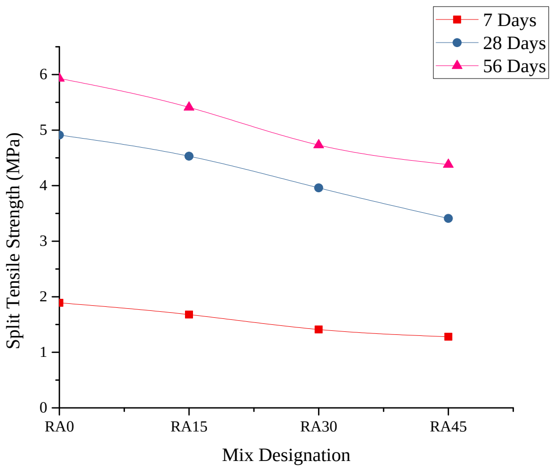


**Chart-3:** Split Tensile Strength Results Vs Mix Designation

The incorporation of recycled coarse aggregate in the concrete causes a decrease in the split tensile strength at all the mixes mainly due to the poor adhesion between the old mortar and aggregate. Split tensile strength has been found to increase with increase in the curing period.

### 5.2.4 Modulus of Elasticity

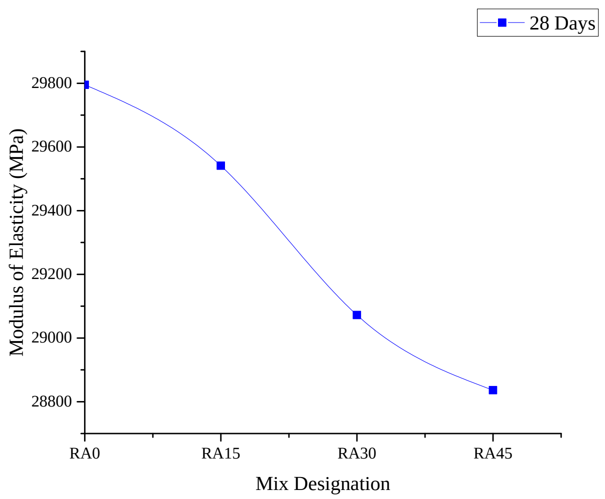


**Chart-4:** Modulus of Elasticity Vs Mix Designation

As percentage of RCA increases, the modulus of elasticity of SCC decreases. However, as expected modulus of elasticity has been found to increase with increase in the curing period.

### 5.2.5 Shear Strength

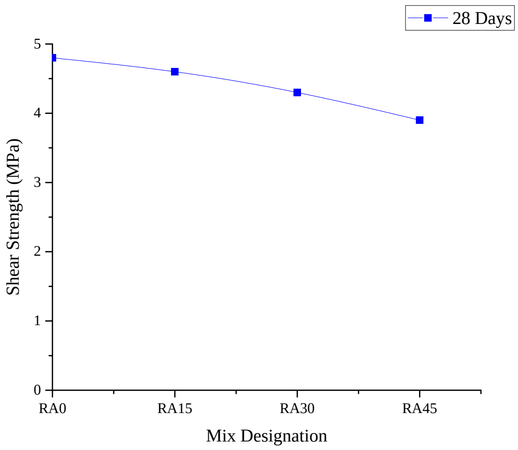


**Chart-5:** Variation of Shear Strength Vs Mix Designation

As percentage of RCA increases, the shear strength of SCC decreases. However, as expected shear strength has been found to increase with increase in the curing period.

## 6. CONCLUSIONS

Following conclusions are drawn based on the results obtained from the experiment.

- According to the study, addition of Fly ash to the concrete, can improve the fresh concrete properties.
- It is possible to produce SCC by combined replacement of FA and GGBS satisfies the criteria for fresh concrete properties such as slump flow, passing ability, filing ability.
- RCA show high water absorption compared with conventional NCA due to the old mortar attached with the original concrete and has relatively lower specific gravity.
- Workability of recycled aggregate was found to be less when compared with NAC.
- The fresh properties such as Slump flow ,V-Funnel ,L-Box values of SCC were satisfied as per EFNARC guidelines
- The compressive strength, flexural strength, split tensile strength and shear strength of SCC decreases with increase in the amount of RCA.

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