

# A Study on Experimental Investigation on the properties of M20 Grade Concrete using Recycled Concrete Coarse Aggregate and Micro Silica

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**ABSTRACT:** Production of cement in large scale is causing environmental problems and also depressions of natural resources. To reduce the environmental problems by using few supplementary materials like silica fume and recycled aggregate by replacing certain amount of cement and natural coarse aggregate. The main parameters investigated in this study are to determine the compressive strength, split tensile strength and flexural strength of concrete on partial replacement of natural coarse aggregate and cement by Recycled concrete aggregate and silica fume respectively. Cubes, Cylinders and Beam specimens were casted and variation in compressive strength, split tensile strength and flexural strength was studied. The maximum size of recycled concrete aggregates which are used is 20mm.

**KEYWORDS:** Recycled concrete coarse aggregate (RCA), Micro Silica, Compressive strength, Split tensile strength, Flexural strength.

## I. INTRODUCTION

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works, including infrastructure, low and high-rise buildings, defense installations, environment protection and local/domestic developments. Buildings which were old enough or reached to their end of service may be demolished and their wastage is becoming problem to dispose. Majority of this waste is used as backfill material, which will create a problem or pollution to the earth. One of the best methods to eliminate to both of these problems is recycled aggregate concrete. Aggregates can be produced from this demolition waste. This will not only utilize the waste but also saves the natural resources. In Australia during the period of 2009-2012 masonry was the largest contributor (37%) to landfill (ABS 2013). Ways to harness the strength from concrete wastes are being investigated.

In fact, many governments throughout the world have now introduced various measures aimed at reducing the use of primary aggregates and increasing reuse and recycling, where it is technically, economically, or environmentally acceptable. For example, the UK government has introduced a number of policies to encourage wider use of secondary and recycled coarse aggregate (RCA- defined as minimum of 95% crushed concrete) as an alternative to naturally occurring primary aggregates. These include landfill and future extraction taxes to improve economic viability, support to relevant research and development work.

## II.SCOPE OF INVESTIGATION

The laboratory investigations were carried out with a water-cement ratio of 0.52. The effect of varying amounts of replacement of natural coarse aggregate that is 20, 30, 40, 50, 60 and 100% with recycled concrete coarse aggregate and cement replaced with 9% silica fume was studied. The quantity of recycled concrete coarse aggregate (40%) and silica fume (9%) was suitably adjusted for the different replacement levels with natural coarse aggregate and cement respectively. The compressive strength, split tensile strength and flexural strength of the mixes were investigated as per IS specifications.

### III. EXPERIMENTAL PROGRAM

#### A. CONCRETE PROPERTIES

The concrete contains Ordinary Portland Cement 43 grade, fine aggregate with fineness 2.79 confirming to zone-II, coarse aggregate with a maximum size of 20mm, water-cement ratio of 0.52 for M20. The main aim of this research project is to utilize recycled concrete as coarse aggregate for the new production of concrete. It is essential to know whether the replacement of recycled concrete coarse aggregate in concrete is inappropriate or acceptable. The three types of aggregates are used in this project which include natural coarse aggregate, natural fine aggregate and recycled concrete coarse aggregate. Also, Cement is replaced with 9% silica fume. Natural fine aggregate used is river sand and recycled concrete coarse aggregate used from demolished concrete waste from which physical test such as specific gravity, water absorption and sieve analysis are carried out. Then concrete cube, prepared for 0%, 20%, 30%, 40%, 50%, 60% and 100% and has been tested for 7, 28, 56 and 90 days for determination of compressive strength. Also, the concrete cylinders and prisms prepared for 0%, 20%, 30%, 40%, 50%, 60% and 100% and has been tested for 28 days. The results at each testing age are reported as an average. The engineering properties of the recycled concrete coarse aggregate and silica fume were also compared to those of the reference concrete.

| Item             | Mass density (Kg/m <sup>3</sup> ) | Remarks            |
|------------------|-----------------------------------|--------------------|
|                  | M20                               |                    |
| OPC              | 320                               | OPC 43 grade       |
| Fine aggregate   | 699                               | S.G 2.58 (ZONE II) |
| Coarse aggregate | 1211                              | S.G 2.74           |
| Water            | 166.4                             |                    |
| W/C ratio        | 0.52                              |                    |

#### B. MIX DESIGN

The mix design is done according the IS design method and numerous trial mixes were conducted to obtain the optimum mix. Once the optimum mix is determined, it is used to produce concrete with 0%, 20%, 30%, 40%, 50%, 60% and 100% replacement of recycled concrete coarse aggregate and 9% silica fume replaced by cement. The concrete is prepared to find out the compressive strength, split tensile strength and flexural strength. The constituents of this optimum mix proportion are shown in the below table.

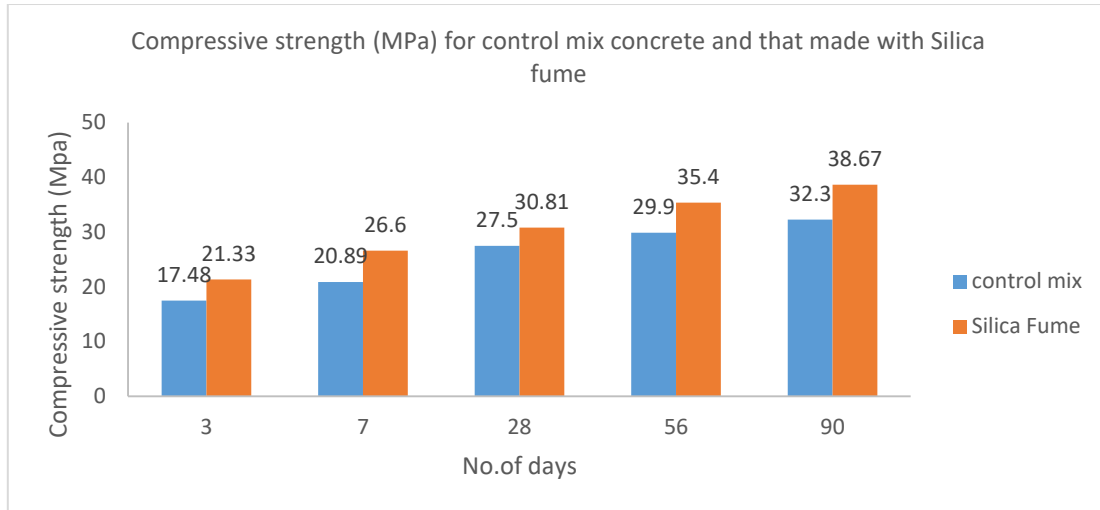
| Grade | Cement (Kg) | Fine aggregate (Kg) | Coarse aggregate (Kg) | Water (Litres) |
|-------|-------------|---------------------|-----------------------|----------------|
| M20   | 320         | 698.63              | 1210.56               | 166.4          |
|       | 1           | 2.21                | 3.76                  | 0.52           |

### IV. RESULTS AND DISCUSSION

#### A. COMPRESSION STRENGTH TEST

Compression test is carried out on specimen of cubical shape. Compression test is done confirming to IS:516-1959. Concrete cubes of size 150mm x 150mm x 150mm were tested for compressive strength.

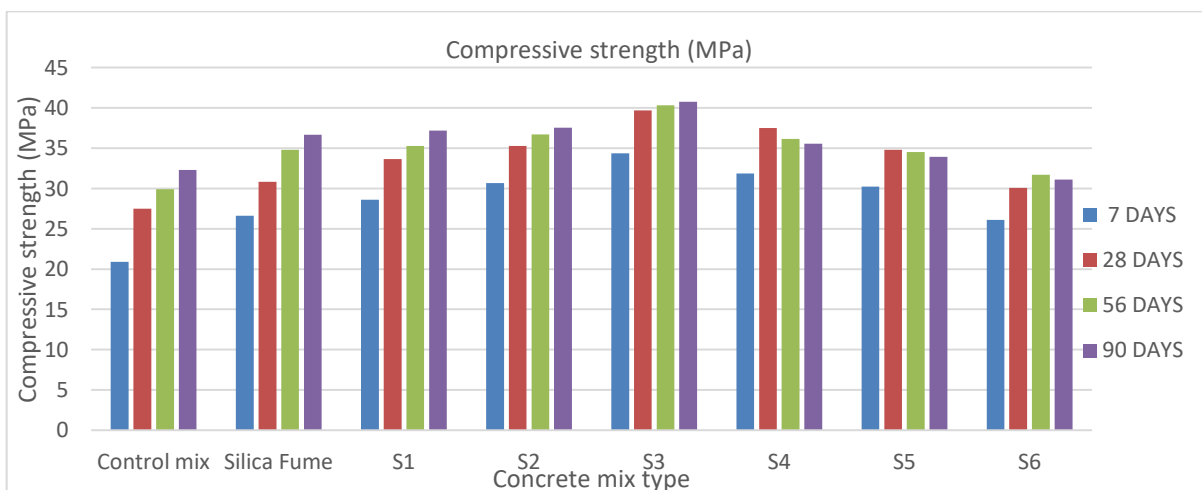
Compressive strength= Max load/ Area of the specimen



**Fig. 1: Variation of compressive strength of concrete for control mix and that made with added 9% silica fume in cement**

As we know the above bar chart represent the compressive strength of concrete of normal aggregate and silica fume added 9% in cement. For 3 days curing period we found compressive strength 17.48 MPa in control mix and 21.33 MPa to that of concrete by adding 9% Silica fume in cement, similarly for maximum curing period of 90 days we found compressive strength of 32.3 MPa in control mix and 38.67 MPa in added 9% silica fume in cement.

**Compressive strength of concrete with recycled concrete coarse aggregate and silica fume replacement:**



**Fig. 2: Compressive Strength Vs % of coarse aggregate and cement replacement by recycled concrete coarse aggregate and Silica fume respectively.**

The above bar chart shows the compressive strength of concrete vs % of natural coarse aggregate and cement by replacement of recycled concrete coarse aggregate and 9% silica fume respectively. The above figure clearly shows the compressive strength of concrete for all six type of combinations increases up to S3 level concrete mix and further increase in recycled coarse concrete aggregate leads to decrease in compressive strength of concrete.

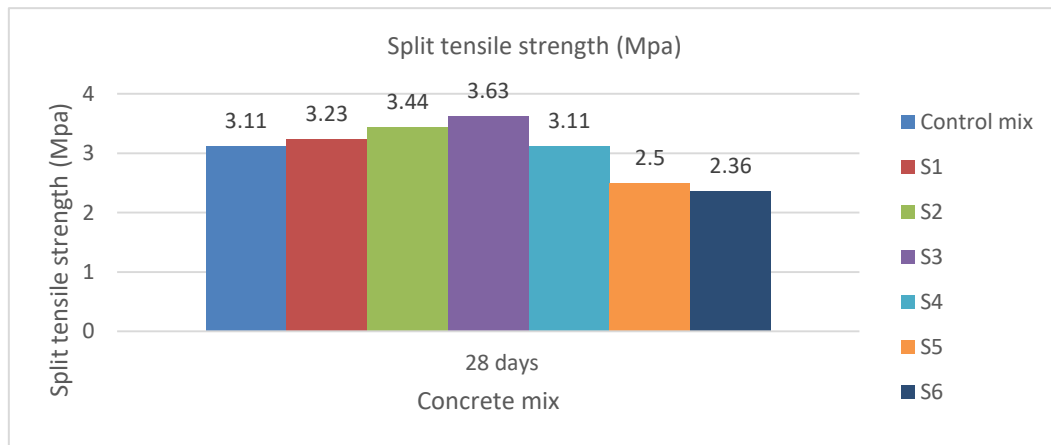
**B TENSILE TESTS**

Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied load itself. However, tensile strength of concrete is very low when compared to its compressive strength. Due to difficulty in applying uniaxial tension to a concrete specimen, the tensile strength of concrete is determined by indirect test methods.

1. Split tensile strength test
2. Flexural strength test

**1. Split tensile strength**

Split tensile strength test was conducted on the specimens at 28 days as per IS:5816-1970. A standard test cylinder of concrete specimen (150 mm x 300 mm) is placed horizontally between the loading surfaces of Compression testing machine. Load at which the specimen failed is recorded and splitting tensile stress is calculated from the formula as  $F_t = 2P/\pi dL$ .



**Fig. 3: Variation of Split tensile strength Vs Age of coarse aggregate and cement by replacement of recycled concrete coarse aggregate and silica fume respectively.**

The above bar chart shows the comparison of results between variation of Split tensile strength Vs Age of coarse aggregate and cement by replacement of recycled coarse concrete aggregate and added silica fume respectively. The split tensile strength of control mix and all six type of different combinations are increases up to S3 level concrete mix, so further increase in recycled coarse concrete aggregate in concrete mix leads to decrease in split tensile strength.

**2. Flexural strength**

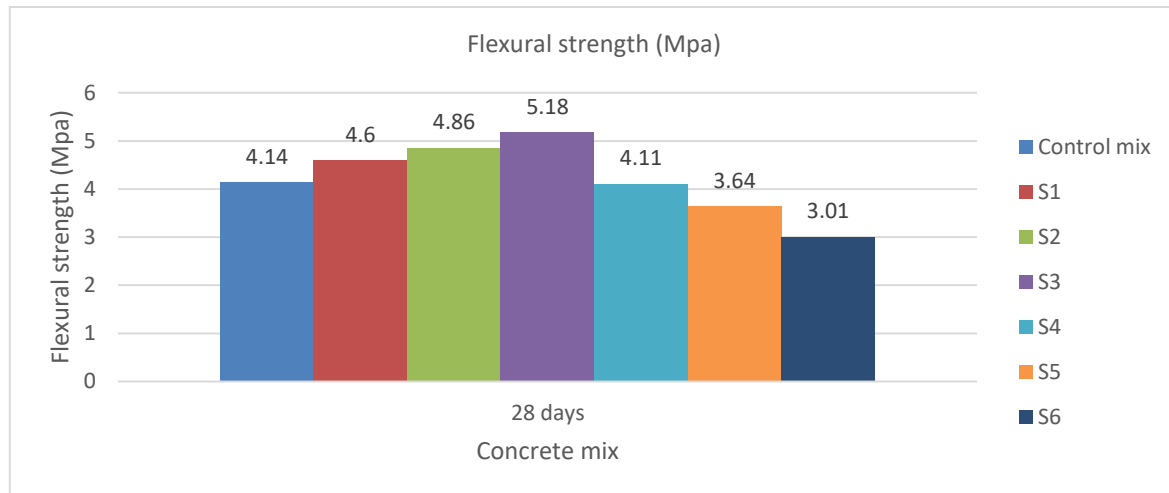
Flexural strength is one measure of the tensile strength of the concrete. The Flexural strength can be determined by standard test method of third point loading or centre point loading. The beam of size 100 mm x 100 mm x 500 mm was used to find the flexural strength. Flexural strength is calculated using the following formula.

- A. When fracture initiates in the tension surface (i.e., the bottom surface) within the middle third of the beam.

$$MR = PL/bd^2$$

- B. If fracture initiates in the tension surface (i.e., the bottom surface) outside the middle third of the beam by not more than 5% of the span length.

$$MR = 3Pa / bd^2$$



**Fig. 4: Variation of Flexural strength Vs Age of coarse aggregate and cement by replacement of recycled concrete aggregate and silica fume respectively.**

The above bar chart shows the comparison of results between variation of flexural strength Vs Age of coarse aggregate and cement by replacement of recycled coarse concrete aggregate and added silica fume respectively. The flexural strength of control mix and all six type of different combinations are increases up to S3 level concrete mix, so further increase in recycled aggregate in concrete mix leads to decrease in flexural strength.

## VI.CONCLUSION

- This investigation indicates favourable results with the use of silica fume in RAC.
- Water absorption of RCA is higher than natural aggregate.
- The compressive strength of concrete containing 9% silica fume in cement increases of 12.5% as compared with conventional concrete at 28 days.
- The compressive strength of concrete containing 40% RCA and 9% silica fume has strength increase of 29.87% with normal coarse aggregate. For the remaining replacements of recycled concrete coarse aggregate and at 9% silica fume when compared with conventional concrete the strength decreases.
- The split tensile strength of concrete containing 40% RCA and 9% silica fume has strength increase of 16.72% with that of normal aggregate concrete.
- The flexural strength of concrete containing 40% RCA and 9% silica fume has strength increase of 14.1% with that of normal aggregate concrete.

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