

# Study of Characteristic Strength of Recycle Aggregate Concrete with Partial Replacement of Cement with Silica Fume

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**ABSTRACT:** Use of recycled aggregate in concrete can be useful for environmental protection. Recycled aggregates are the materials for the future. The use of recycled aggregate has been started in a large number of construction projects in many European, American, Russian and Asian countries. Many countries are giving infrastructural laws relaxation for increasing the use of recycled aggregate. This thesis reports the basic properties of recycled coarse aggregate with partial replacement of cement with silica fumes & also compares these properties with natural aggregates. Basic changes in all aggregate properties are determined and their effects on concreting work are discussed at length. Similarly the properties of recycled aggregate concrete are also determined. Basic concrete properties like compressive strength, flexural strength, split tensile strength, workability, water absorption, density etc. are explained here for different combinations of recycled aggregate with partial replacement of cement with silica fumes variation (0%, 2%, 3%, 4%, 5% & 6%) for M<sub>30</sub> harden concrete.

**KEY WORDS:** Silica fume, RCA, RAC, Compressive strength, Split tensile strength, Flexural strength.

## I. INTRODUCTION

The term RAC refers to recycled aggregate concrete and it is defined as the concrete prepared by using recycled aggregates or the combination of recycled aggregates and natural aggregates. The recycled aggregates may consist of either fine aggregates or recycled coarse aggregates which are obtained by crushing manually or various manufacturing system of old Concrete structures such as old Buildings, RCC roads, Bridges, tunnel and under water concrete structures sometimes even from catastrophes, such as wars and earthquakes. Developed and developing countries in all over world continues increasing of urbanization, modernization of infrastructure, industrialization which causes the serious problems in construction and demolition waste disposal(C&D) and economically onerous with regard to difficulty to finding new area. In spite with the use of natural resources the energy consumption increases rapidly. This is also major cause for negative impact on the environment.

Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industry. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of RAC. To achieve this, major emphasis must be laid on the reuse of wastes concrete aggregates as recycled aggregates for new constructions. In the present study the recycled coarse aggregate was obtained from concrete laboratory waste. Recycling is the act of processing the used material for use in recreating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. There are many advantages of using the recycled aggregate.

The recycling and reuse of construction & demolition wastes seems feasible solution in rehabilitation and new constructions after the natural disaster or demolition of old structures. This becomes very important especially for those

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countries where national and local policies are stringent for disposal of construction and demolition wastes with guidance, penalties, levies etc. In many densely populated countries of Europe, where disposal of debris problem is becoming more and more difficult, the recycling of demolition waste has already been started. As per the survey conducted by European Demolition Association (EDA) in 1992, the several recycling plants were operational in European countries such as 60 in Belgium, 50 in France, 70 in the Netherlands, 120 in United Kingdom, 220 in Germany, 20 in Denmark and 43 in Italy. The recycling of construction & demolition waste becomes easy & economical, wherever combined project involving demolition and new construction are taken up simultaneously. About 1,300 million tones of waste are generated in Europe every year, of which about 40% or 510 million tones, is construction and demolition (C&D) waste. The US produces about 325 million tones of construction and demolition (C&D) waste, and Japan about 77 million tones. Given that China and India are now producing and using over 50% of the world's concrete, their waste generation will also be significant as development continues.

### Following are the main reasons for the use of demolition concrete waste:-

- i. The old age of various building, RCC bridges, concrete pavement etc., have limit of use due to structure deterioration and beyond their repairs need to be demolished.
- ii. Some concrete structures not serving in present scenario need to be demolished.
- iii. New construction for better economic growth;
- iv. Structures are turned into debris resulting from natural disasters like earthquake, cyclone and floods etc.
- v. Building waste produced from manmade disaster/war.

## II. MATERIALS AND METHODS

**Materials Used:** Details are presented in table below

**Table I: Details of material used**

Name of the Material	Source of the materials
Cement	OPC manufactured by Reliance
Silica Fumes	Krishna UdiyogBhardhhaman
Tap water	Laboratory BIT Sindri, Dhanbad
RCA	Laboratory test material BIT Sindri, Dhanbad
Fine Aggregate	Kandra local market, Dhanbad

### Methods

#### Testing of cement

Ordinary Portland Cement conforming to IS:8112 were used in the entire experimental study. To avoid the long storage times and to avoid the loss of strength, cement was procured according to the phase wise requirement. The cement was stored in bags in air tight room to have minimum exposure to humidity. The detail of physical properties of cement is presented in table II.

**Table II: Physical and mechanical properties of cement**

Properties	Results	Standard Limits (IS: 8112)
Consistency	25%	—
Soundness	Expansion 2 mm	<10mm
Initial setting time (min)	110 minutes	>30 min
Final setting time	252 minutes	<600 min
Specific gravity	3.123	—

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Fineness	4% Retain on 90 micron sieve	<10%
Compressive strength	N/mm <sup>2</sup>	N/mm <sup>2</sup>
1. 3days	23.40	>23
2. 7days	34.06	>33
3. 28 days	45.20	>43

According to table II, the test results within standard limits.

### Testing of aggregate

Aggregates are the important constituents in concrete. The fact that the aggregates occupy 70-80% of volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. The test results conducted on fine and coarse aggregate for this thesis are given in table III and IV respectively.

**Table III: Tests of Fine Aggregate**

S. No.	Test	Fine Aggregate
1	Zone	II
2	Moisture Content	0.5%
3	Specific Gravity	2.620
4	Fineness Modulus	2.78
5	Water Absorption	1.10%
6	Unit Weight	1.62gm/cc

**Table IV: Tests of Coarse Aggregate**

S. No.	Test	N C A	RCA
1	Moisture content	1.20 %	1.30 %
2	Water absorption	0.55 %	1.70 %
3	Specific gravity	2.89	2.58
4	Crushing value	29.42 %	34.93 %
5	Impact value	14.50 %	23.50 %
6	Elongation Index	18.40%	12.98%
7	Flakiness Index	7.25%	6.52%

### Selection of mix design

The experimental investigation consisted of making M<sub>30</sub> concrete was designed as per IS 10262:2009 and the mix proportions are given in Table V.

**Table V: Quantity of Materials for M<sub>30</sub> Concrete**

Water	Cement	fine aggregate	coarse aggregate
201kg/m <sup>3</sup>	445kg/m <sup>3</sup>	635kg/m <sup>3</sup>	1214 kg/m <sup>3</sup>
0.43	1	1.42	2.72

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## Normal water curing

Water unsuitable for drinking is generally considered unsuitable for curing concrete as well. The water used for normal water curing of concrete samples was taken from concrete technology laboratory, B.I.T Sindri. The concrete samples were tested after 7 and 28 days of proper curing.

**Table VI: NOMENCLATURE**

Concrete mix sample code	Description
S <sub>0</sub>	Replacement of 0% silica fumes by weight of cement
S <sub>2</sub>	Replacement of 2% silica fumes by weight of cement
S <sub>3</sub>	Replacement of 3% silica fumes by weight of cement
S <sub>4</sub>	Replacement of 4% silica fumes by weight of cement
S <sub>5</sub>	Replacement of 5% silica fumes by weight of cement
S <sub>6</sub>	Replacement of 6% silica fumes by weight of cement

## III. RESULTS AND DISCUSSION

### Study of hardened concrete

The most valuable property in concrete is the compressive strength because it gives the overall quality of hardened concrete. The hardened concrete tests conducted were compressive strength test, split tensile test and the flexure strength test.

### Compressive strength test

The compressive strength test was conducted on 150 mm size of cubes after 7 and 28 days after curing process. The compressive strength is determined using 2000 KN compression testing machine in accordance with IS: 516-1959. The values of compressive strength for different percentage replacement of cement with silica fume after 7 and 28 days of given in table VII & fig.1.

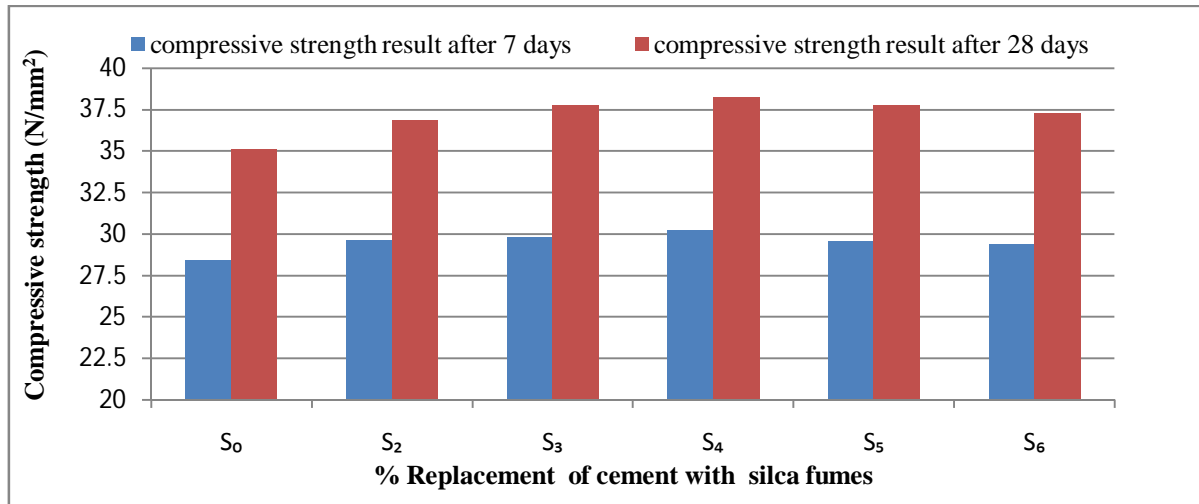
**Table VII: Compressive strength test result for recycle aggregate concrete after 7 and 28 days.**

Mix Designation	Silica Fumes variation (%)	Compressive Strength(N/mm <sup>2</sup> ) after 7 Days	% Increase Strength after 7 days	Compressive Strength(N/mm <sup>2</sup> ) after 28 Days	% Increase Strength after 28 days
S <sub>0</sub>	0	28.44	0%	35.11	0%
S <sub>2</sub>	2	29.62	4.10%	36.88	5.04%
S <sub>3</sub>	3	29.77	4.67%	37.74	7.49%
S <sub>4</sub>	4	30.22	6.25%	38.22	8.85%
S <sub>5</sub>	5	29.55	3.90%	37.77	7.57%
S <sub>6</sub>	6	29.41	3.41%	37.27	6.15%

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**Fig.1 Compressive strength test after 7 and 28 days.**

From fig.1, it was found that the compressive strength of recycle aggregate concrete after 7days and 28 days are below the target strength. But on partial replacement of cement with silica fumes compressive strength increases. Up to 4% replacement gives the optimum result.

### Split tensile strength test

This test was conducted using 1000 KN compression testing machine as per the procedure given in IS: 5816-1999. The split tensile strength test was conducted on cylindrical specimens of 150 mm diameter x 300 mm height after 7and 28 days.

The values of split tensile strength for different percentages of partial replacement of cement with at 7 and 28 are given in table VIII & fig. 2.

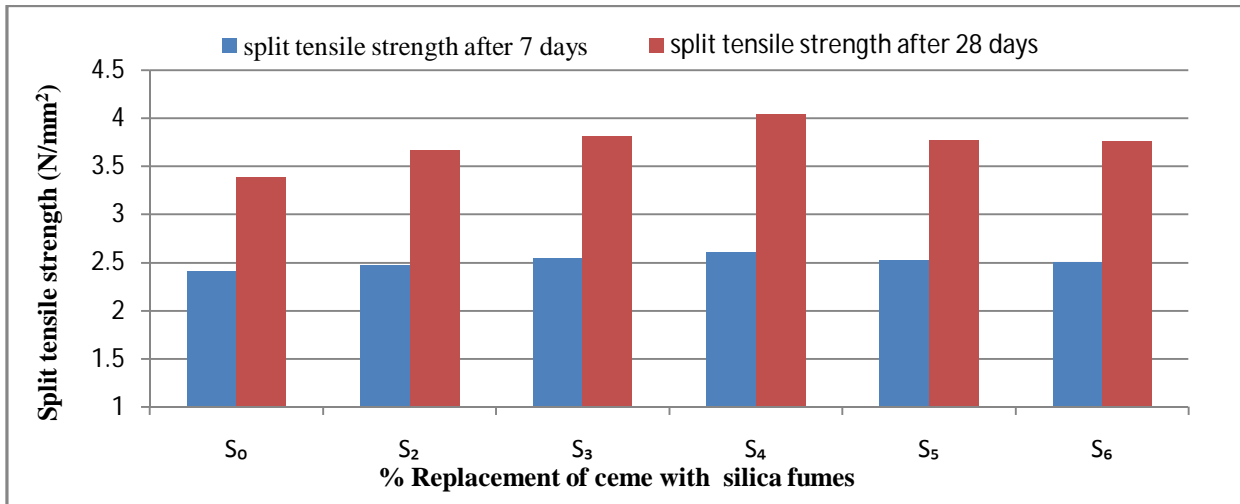
**Table VIII: Comparative study of split tensile strength after 7& 28 days.**

% of silica fumes	Split tensile strength after 7 days(N/mm <sup>2</sup> )	Split tensile strength after 28 days(N/mm <sup>2</sup> )	% increase of strength after 7 days(N/mm <sup>2</sup> )	% increase of strength after 28 days(N/mm <sup>2</sup> )
0%	2.405	3.395	0%	0%
2%	2.475	3.670	2.91%	8.10%
3%	2.546	3.811	5.86%	12.22%
4%	2.617	4.010	8.81%	18.11%
5%	2.518	3.770	4.69%	11.405%
6%	2.506	3.764	4.19%	10.868%

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**Fig.2 Split Tensile Strength test after 7 and 28 days.**

From fig.2, it was observed that the split tensile strength of fibre reinforced concrete with 0.25% addition of fibre is more than the split tensile strength of fibre reinforced concrete with other percentage addition of fibre. The treated fibre reinforced concrete has more strength as compared to untreated fibre reinforced concrete for both normal water and acidic curing. Also, the split tensile strength of fibre reinforced concrete with normal water curing is more than the split tensile strength of fibre reinforced concrete with acidic curing.

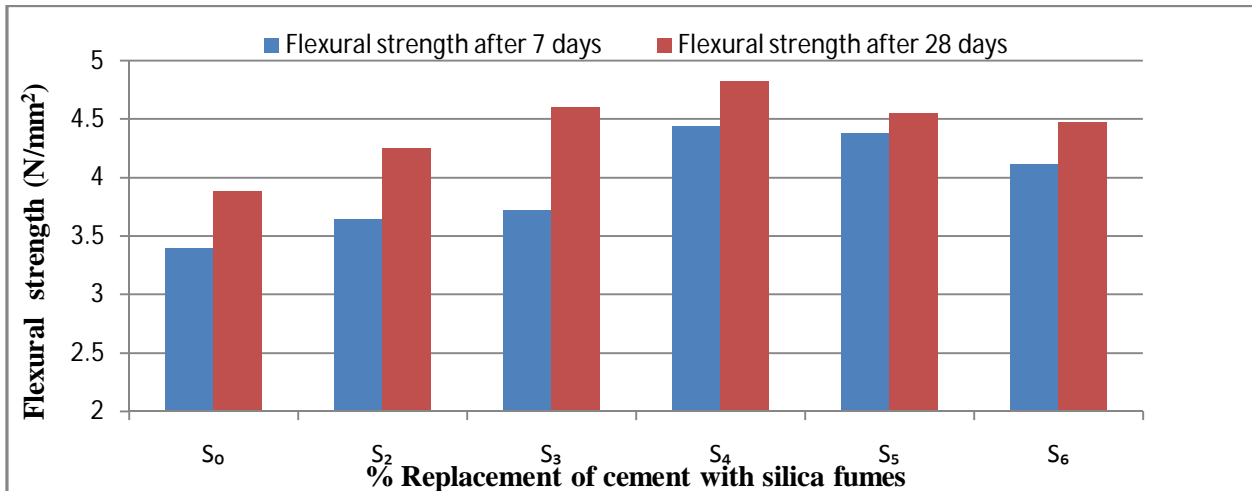
### Flexural Strength Test

The flexural strength test was performed in accordance with IS: 516-1959 on the beams of size 500 x 100 x 100 mm after curing period of 7 and 28 days with 200 kN universal testing machine. The specimen was supported on two roller support spaced at 400 mm center to center.

The values of flexural strength for different percentages replacement of cement with silica fumes of recycle aggregate concrete of Normal water curing are given in table IX & fig.3.

**Table IX: Comparative Study of Flexural Strength after 7 & 28 days**

% Of Silica Fumes	Flexural Strength after 7 days(N/mm <sup>2</sup> )	Flexural Strength after 28 days(N/mm <sup>2</sup> )	% Increase of strength after 7days(N/mm <sup>2</sup> )	% Increase of Strength after 28days(N/mm <sup>2</sup> )
0%	3.400	3.880	0%	0%
2%	3.640	4.250	7.05%	9.53%
3%	3.720	4.600	9.41%	18.55%
4%	4.440	4.820	30.58%	24.22%
5%	4.380	4.550	28.28%	17.26%
6%	4.120	4.478	21.17%	15.41%



**Fig.3 Flexural strength test after 7 and 28 days.**

From fig.3, it was observed that the flexural strength of recycled aggregate concrete with 4% partial replacement of cement with silica fume is more than the flexural strength with other percentage replacement of cement with silica fume.

#### IV. CONCLUSIONS

It may be concluded that-

- The specific gravity and bulk density of recycled coarse aggregate is less than that of natural coarse aggregate.
- The presence of adhered mortar on recycled coarse aggregate produces porous and rough nature of surfaces, which help in developing better bond. But for achieving required workability, the water absorption for recycled coarse aggregate is more than natural aggregate.
- The recycled aggregate concrete has less workability as compared to the concrete made of natural aggregate; this is due to the porous and rough surfaces of the recycled aggregate.
- The compressive strength, split tensile strength and flexural strength of recycled aggregate concrete are less than natural aggregate concrete due to pores present in old mortar which developed honeycomb making weaker bond.
- The optimum percentage replacement of cement with silica fumes can be used to recycle aggregate concrete is 4%.

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