Experimental Investigation of Recycled Coarse Aggregates on Partial Replacement of Cement with Silica Fume

SManivel1, NPannirselvam2, JRajprasad3, T.SHemanarayanan.4
1Assistant Professor, Department of Civil Engineering,
2Associate Professor, Department of Civil Engineering,
3Assistant Professor (Sr.G), Department of Civil Engineering,
4PG Student, Department of Civil Engineering,
SRM Institute of Science and Technology, Potheri, Kattankulathur 603203, Chengalpattu District, Tamilnadu, India.
Corresponding Author Email: 2pannirsn@srmist.edu.in

Abstract. Coarse aggregate utilized majorly in concrete to reach the ultimate quantity in larger proportion. The structural and non-structural elements in the construction utilize majorly the concrete. Due to the mass availability of concrete during the demolition process and hence absorbing the same material to replace the coarse aggregate with recycled aggregate is the emerging field and it is sustainable. The experimental work involving the replacement of coarse aggregates with recycled aggregates and cement with silica fumes to improve the properties of concrete and eliminate the difficulties in construction field paves way for the further researches. The experimental study concentrates in the strength properties of the concrete with recycled aggregates and silica fume and compared with the conventional concrete.

Keywords: Compressive strength, Recycled coarse aggregate, Silica fume.

1. Introduction
Concrete is a combination of cement, fine grained particles and coarse aggregates binded with water and hardens due to many external factors. Several structural elements such as slabs, columns, beams, footings and lintels etc. are built using concrete. In recent years, many researches have been done in the replacement of components of concrete with the chemicals, fibres, agro wastes, construction and demolition wastes.

Concrete is brittle and possess good compression but weak in tension. The presence of cement causes cracking of beams, columns and cannot be operated if the moisture of soil is above 10%. The disposal of cement causes emission of carbon dioxide, which affects the environment and causes pollution. Hence the cement can be partially replaced with silica fume[1-3]. Silica fume possess higher fineness texture and has extreme amorphous silica content, so this silica based fume can act as a high reactive factor because of its pozzolanic reaction [8, 12]. The main advantage of the silica fume on addition to the concrete ensures durability enhances flexural and compressive strength [4-6].

In recent years, the usage of recycled coarse aggregate (RC) have an effective potential in production of concrete is more considerate, as it is environmentally concerned and conserves the natural resources. Construction and demolition activities accounted for 375million and from the demolition of bridge sand roads produces huge amount of debris. Disposal of this aggregate creates an issue on waste disposal and increase in cost of waste treatment prior to disposal. Recycled concrete aggregates from demolished building or structures used in production of
concrete [9-11].

2. Objectives

The important objectives of the research includes:

- To optimize the addition of percentage of recycled aggregate.
- To optimize the addition of percentage of silica fume.
- To observe the compressive strength of addition of 10, 20 and 30% of recycled aggregate along with 10, 15 and 20% of silica fume.

3. Materials

3.1 Silica Fume

The particle size of the silica fume adopted for the experimental work is 150 nano meter and shown in Figure 1. The specific gravity of coarse aggregate is 2.24.

![Figure 1. Silica fume.](image1.png)

3.2 Recycled Coarse Aggregate

Recycled aggregates are the aggregates which are the resultant product from the construction demolition wastes. It is adopted in the mixing of concrete by partially substituting the natural aggregates shown in Figure 2.

![Figure 2. Recycled coarse aggregate.](image2.png)
3.3 M sand

M sand also called as quarry powders, quarry minerals, quarry flour, soil demineralization and mineral fines having finely crushed rock, obtained by natural or mechanical means, which contains minerals and trace elements largely used in organic farming cultures are shown in Figure 3. The test results are presented in Table 1.

| Property of material | Results       |
|----------------------|---------------|
| Specific gravity     | 2.47          |
| Fineness modulus     | 3.98          |
| Sieve analysis       | Zone II       |

3.4 Coarse aggregate

A property of coarse aggregate consists of porosity, density, grading, shape and surface texture which evaluates the characteristics of concrete mixtures. The coarse aggregates used in the experimental work is shown in Figure 4. The specific gravity of coarse aggregate is 2.74.

3.5 Cement

The cement used in the research work from the locally available market of 53 grade are shown in Figure 5. The physical properties of cement presented in Table 2.
Table 2. Properties of cement

| Properties of material     | Results   |
|----------------------------|-----------|
| Cement consistency         | 31%       |
| Cement fineness            | 5%        |
| Initial setting time       | 39 minutes|
| Final setting time         | 489 minutes|
| Specific gravity           | 3.14      |

Figure 5. Cement.

3.6 Water

Water was one of the most environmental elements in construction it increase the engineering properties of fine-grained particles.

4. Methodology

The cubes were casted and checked for compressive strength and the flexural properties. These tests are accomplished to examine the characteristics of toughness of concrete without admixtures and on addition of these additives, the rate of strength and enhancement of durability can be found. The design mix were calculated for M40 conventional concrete and concrete with silica fumes of proportions 10, 15 and 20%. A concrete mix proportions of 1: 1.5: 2.65 with water cement ratio of 0.40 under laboratory conditions.

5. Results and discussion

The compressive, split tensile and flexural strength of the specimen after curing are tabulated in Table 3.

Table 3. Compressive, Split Tensile and Flexural Strength.
### Table 1: Compressive Strength, Split Tensile Strength, and Flexural Strength of Various Samples

| S.No. | Sample                      | Compressive strength, N/mm² | Split tensile strength, N/mm² | Flexural strength, N/mm² |
|-------|-----------------------------|-------------------------------|-------------------------------|--------------------------|
|       |                             | 7 Days                        | 28 Days                       | 28 Days                  | 28 Days                  |
| 1     | Control specimen            | 27.33                         | 38.16                         | 3.76                     | 5.48                     |
| 2     | 10% silica 10% RC          | 24.10                         | 34.90                         | 3.48                     | 5.39                     |
| 3     | 10% silica 20% RC          | 24.86                         | 30.16                         | 3.02                     | 5.22                     |
| 4     | 10% silica 30% RC          | 25.38                         | 29.74                         | 2.89                     | 4.97                     |
| 5     | 15% silica 10% RC          | 25.47                         | 33.27                         | 3.33                     | 5.24                     |
| 6     | 15% silica 20% RC          | 26.92                         | 36.77                         | 3.68                     | 5.88                     |
| 7     | 15% silica 30% RC          | 26.28                         | 31.14                         | 3.24                     | 5.42                     |
| 8     | 20% silica 10% RC          | 25.80                         | 32.86                         | 3.29                     | 5.10                     |
| 9     | 20% silica 20% RC          | 26.44                         | 34.13                         | 3.43                     | 5.32                     |
| 10    | 20% silica 30% RC          | 24.69                         | 29.75                         | 2.89                     | 4.72                     |

### 6. Conclusions

The addition of percentage of recycled aggregate at 20% with addition of 15% silica fume are optimized. The compressive strength of addition of 20% of recycled aggregate along with 15% of silica fume at 28 days is 36.77 N/mm². Further addition leads to reduction of compressive strength. The split tensile strength of addition of 20% of recycled aggregate along with 15% of silica fume at 28 days is 3.68 N/mm². The flexural strength of addition of 20% of recycled aggregate along with 15% of silica fume at 28 days is 5.88 N/mm².

### 7. References

[1] Belen G F, Fernando M A, Isabel M Land Javier E L 2009 Structural shear behavior of recycled concrete with silica fume *Constr. Build. Mater.* 23 3406–10.

[2] Chakradhara Rao M 2011 Recycled coarse aggregate and its use in concrete *ICI journal* 27–40.

[3] Elhakam A A, Mohamed A E M and Awad E 2012 Influence of self healing, mixing method and adding silica fume on mechanical properties of recycled aggregates concrete, *Constr. Build. Mater.* 35 421–7.

[4] Evangelista L and De Brito J 2007 Mechanical behavior of concrete made with fine recycled concrete aggregates *Cem. Concr. Compos.* 29 397–401.

[5] Huda S B and Alam M S 2014 Mechanical behavior of three generations of 100% repeated recycled coarse aggregate concrete *Constr. Build. Mater.* 65 574–82.

[6] Kou S and Poon C 2008 Long-term mechanical and durability properties of recycled aggregate concrete prepared with the incorporation of fly ash *Cem. Concr. Compos.* 37 12-19.

[7] Pinghua Zhu,YaliHao, Hui Liu, Da Wei, Shao Feng Liu and Lei Gu 2019 Durability evaluation of three generations of 100% repeatedly recycled coarse aggregate concrete *Constr.*
Priyanka and Musaib Mehraj Bhat 2015 Study the effect of fly ash, silica fume and recycled aggregate on the compressive strength of concrete aggregate on the compressive strength of concrete, *International journal of research in engineering and advanced technology*, 3: 71-7.

Rao A, Jha K N, and Misra S 2007 Use of aggregates from recycled construction and demolition waste in concrete *Resources, conservation and recycling* 50: 81–91.

Ryu J S 2002 An experimental study on the effect of recycled aggregate on concrete properties *Magazine of concrete research* 54: 7–12.

Tushar R Sonawane and Sunil Pimplikar 2013 Use of recycled aggregate concrete *Journal of mechanical and civil engineering* 52-9.

Ozgur Cakir and Omer Ozkan Sofyanli 2015 Influence of silica fume on mechanical and physical properties of recycled aggregate concrete *Housing and building national research center* 11: 157-66.