A STUDY ON THE EFFECT OF SILICA FUME ON THE PROPERTIES OF RECYCLED AGGREGATE CONCRETE

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ABSTRACT

Making use of demolished waste of reinforced concrete structures is one of the possibilities of reducing waste management and saving natural aggregates. This study presents an experimental investigation on the effect of silica fume (SF) on various strength properties of recycled coarse aggregate (RCA) concrete. In the present investigation, recycled coarse aggregate was used as 10%, 20%, 30%, 40% and 50% replacement of natural coarse aggregate in addition to silica fume partially replaces 10% of cement by weight. Properties such as Density, Water absorption, Compressive strength and Split tensile strength for M40 grade of concrete was prepared using recycled coarse aggregate and silica fume were studied and the results are compared with the natural coarse aggregate concrete.

KEYWORDS*: Recycled coarse aggregate concrete, Silica fume, Density, Water absorption, Compressive strength, Split tensile strength.*

I. INTRODUCTION

Concrete is the most common construction material prepared using cement, natural aggregates and water. With fast industrialization, infrastructure development and increase in the population leads to huge construction activities and thus the collapse of reinforced concrete buildings causes very large quantities of demolished concrete waste material.

To preserve the natural resources for our future, the concrete waste can be used to obtain coarse aggregate known as recycled coarse aggregate. The use of recycled coarse aggregate in the preparation of new concrete has various environmental benefits also. Hence, recycling of the concrete waste can be considered as an excellent source of coarse aggregate

for the production of new concrete. It has been observed that the recycled coarse aggregate obtained from concrete waste is rough-textured, angular and has higher water absorption than the natural coarse aggregate affecting the concrete mix proportion.

Kumutha et al., (2008) has investigated on the strength parameters of concrete made with partial replacement of aggregate by recycled coarse aggregate and further the density of recycled concrete aggregate is less than the natural coarse aggregate because of the porous and less dense residual mortar adhering to the surface.

Sivakumar et al., (2014) have studied the effect of micro silica and the strength of concrete with ordinary Portland cement. They observed that silica fume increases the strength of concrete and reduces capillary pores. N.K.Amudhavalli et al., (2012) studied the influence of silica fume on concrete and found that 10-15% of silica fume replacement increases the maximum compressive strength and split tensile strength.

Kalaiarasu et al., (2006) have observed the mechanical properties of high performance concrete with micro silica and in combination with recycled coarse aggregate.

The preliminary study says that as the percentage of recycled coarse aggregates increased the strength of the recycled coarse aggregate concrete is decreased. The present paper is focused on to understand the effect of silica fume on the strength properties of recycled coarse aggregate concrete. Compressive strength and split tensile strength of recycled coarse aggregate concrete with the addition of 10% silica fume were obtained using concrete specimens and then the results were compared with the natural coarse aggregate concrete.

II. EXPERIMENTAL PROGRAM

2.1.MATERIALS USED

2.1.1.CEMENT

In the present investigation OPC 53 Grade PENNA brand cement confirming to IS: 12269-(1987) was used and its properties are tabulated in Table 1.

Table 1: Properties of Cement

Sl.No	Physical properties of cement	Results
1	Specific gravity	3.15
2	Standard consistency (%)	28%
3	Initial setting time (min)	35

4	Final setting time (min)	500
5	Compressive strength at 28 days	53.21 N/mm^2

2.1.2. FINE AGGREGATE

The fine aggregate used in this experimental investigation was natural river sand confirming to zone II as per IS: 383-1987. The properties of fine aggregate are shown in Table 2.

2.1.3. COARSE AGGREGATE

Crushed aggregates particles passing through 20mm and retained on 10mm I.S sieve was used as natural aggregates which met the grading requirements. The properties of coarse aggregate are shown in Table 2.

Table 2: Properties of Aggregates

Properties of aggregates	**Fine aggregates**	**Natural coarse aggregate**	**Recycled coarse aggregate**
Specific gravity	2.648	2.74	2.49
Fineness modulus	2.8	7.4	_
Water absorption	0.815%	0.195%	2.75%
Impact value	_	16.73%	24.645%
Grading of sand	Zone II	_	_

2.1.4.SILICA FUME

It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production that was purchased from Moon Traders, Madurai. The addition of silica fume act as a pozzolanic material for high performance concrete.

Table 3: Properties of silica fume

1	Color	Grey
2	SiO_2	90% ±2%
3	pH	8
4	Mesh size	Less than 45microns 94%
5	Moisture	Less than 1%

6	Specific surface area	20sq.cm/gm
7	Bulk density	600-650 kg/m^3

*As per manufactures manual

2.1.5.SUPER PLASTICIZER

Commercially available super-plasticizer SUPAFLO PC 711 was utilized in this study to achieve a vertical slump of 75 mm.

2.2. MIX PROPORTIONING

Concrete mix design for M40 grade in this experiment was designed as per the guidelines specified in I.S. 10262-1982. The Table 4 shows mix proportion of concrete.

Table 4: Mix proportioning

Water content	**Cement content**	**Fine aggregate**	**Coarse aggregate**
172 kg/m^3	430 kg/m^3	652 kg/m^3	1208 kg/m^3
0.40	1	1.51	2.79

III. EXPERIMENTAL METHODOLGY

The specimen of standard cube of 150mm x 150mm x 150mm and cylinders of 300mm x150mm were used to determine the compressive strength, split tensile strength of concrete. For each proportion of recycled coarse aggregate and silica fume replacement six cubes and two cylinders were casted. The constituents were weighed and the materials were mixed by machine mixing and vibrated by hand compaction. The recycled coarse aggregate is replaced by 10% to 50% for the first batch of concrete mix and then silica fume replacing 10% by weight of cement with recycled coarse aggregate were casted. The water cement ratio adopted was 0.40 through all the mix proportions. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 and 28 days and Compression Testing Machine (CTM) with capacity of 2000KN were used to test its compressive strength and split tensile strength.

IV. RESULTS AND DISCUSSIONS

4.1. DENSITY OF CONCRETE

The density of all concrete mixes at 28 days curing was presented in Table 3. Density of concrete mixes ranges from 2546 to 2728 kg/m^3. The decrease in density of concrete can be observed as the percentage increases in recycled coarse aggregate. Figure1 shows the variation in density with varying recycled coarse aggregate.

Table 5: Test results of average compression and split tensile strength

Mix	Identifications	Average density at 28 days (kg/m^3)	Water absorption %	Average compressive strength at 7 days (N/mm^2)	Average compressive strength at 28 days (N/mm^2)	Split tensile strength at 28days (N/mm^2)
1	RC –control concrete	2695.16	0.54	38.38	47.77	4.05
2	RA 10	2642. 35	0.52	34.90	48.44	3.89
3	RA20	2692.15	0.66	31.70	46.67	3.86
4	RA30	2594.48	0.67	26.55	39.87	3.82
5	RA 40	2567.29	0.66	28.26	37.52	3.65
6	RA50	2546.78	0.69	24.45	33.49	3.61
7	NS10	2728.85	0.50	38.07	51.53	4.21
8	RA 10S	2690.36	0.59	36.52	50.14	3.84
9	RA20S	2638.36	0.65	38.32	50.73	3.89
10	RA30S	2637.03	0.67	40.53	47.6	3.87
11	RA40S	2554.32	0.67	32.16	42.36	3.84
12	RA50S	2588.87	0.65	30.28	39.24	3.79

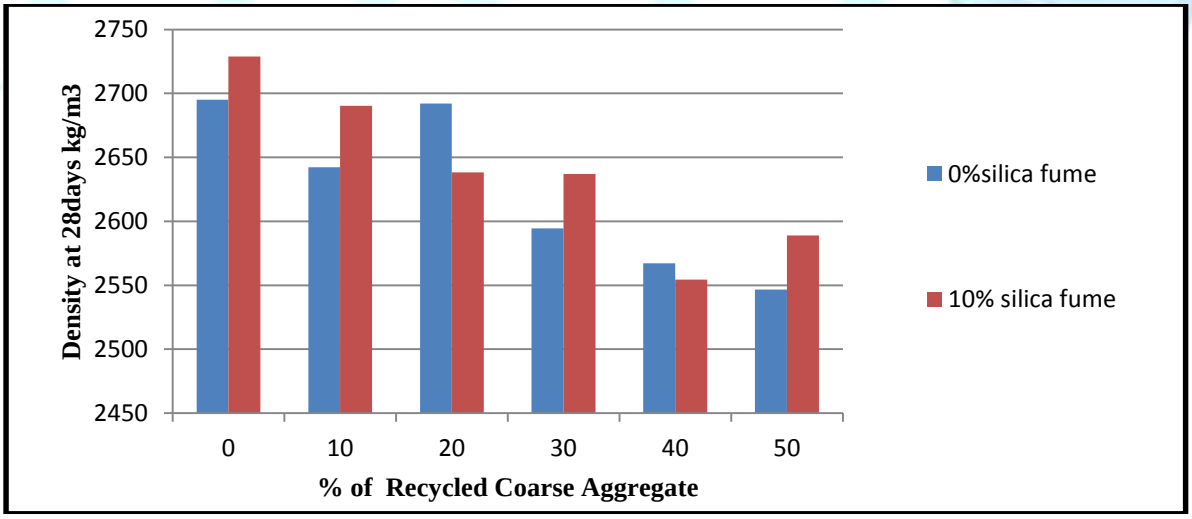

Figure 1: Effect of recycled coarse aggregate and silica fume on density of concrete

4.2. WATER ABSORPTION

The results of water absorption tests are tabulated in Table 5. From the results it was noted that the percentage water absorption of concrete containing recycled aggregates are

higher compared to that of concrete mix without recycled aggregates. Because of attached mortar recycled aggregate has higher water absorption.

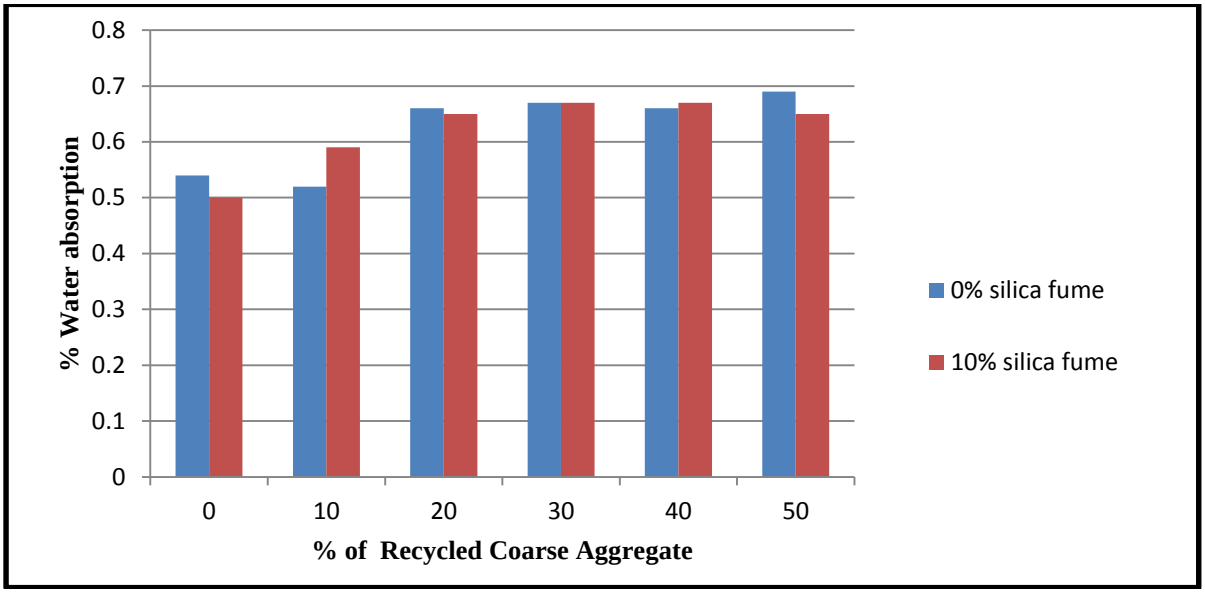

Figure 2: Effect of recycled coarse aggregate and silica fume on water absorption of concrete

4.3. COMPRESSIVE STRENGTH

The variation of compressive strength at 7 and 28 days were presented in figure 3 & 4. The results show that with increasing the volume of recycled coarse aggregate in concrete may results in lowering the cube compressive strength. In addition of 10% silica fume will increase the strength of all mixes in optimum percentage. The maximum compressive strength at 7days was observed at 30% replacement of recycled coarse aggregate which replaces the cement by 10% of silica fume. The mix that casted with the replacement of silica fume gives a significant improvement in the compressive strength of concrete because of the high pozzolanic nature of the silica fume.

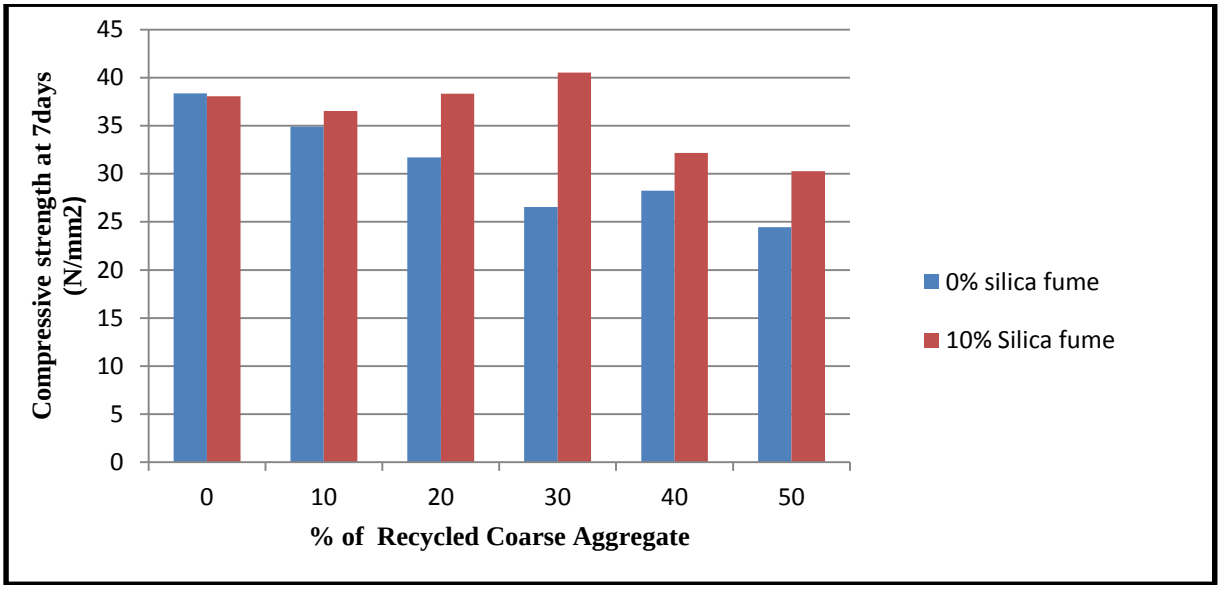

Figure 3: Effect of recycled coarse aggregate on compressive strength of concrete at 7days

When pozzolanic material, i.e siica fume are added to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate, which improve the mechanical properties of concrete.

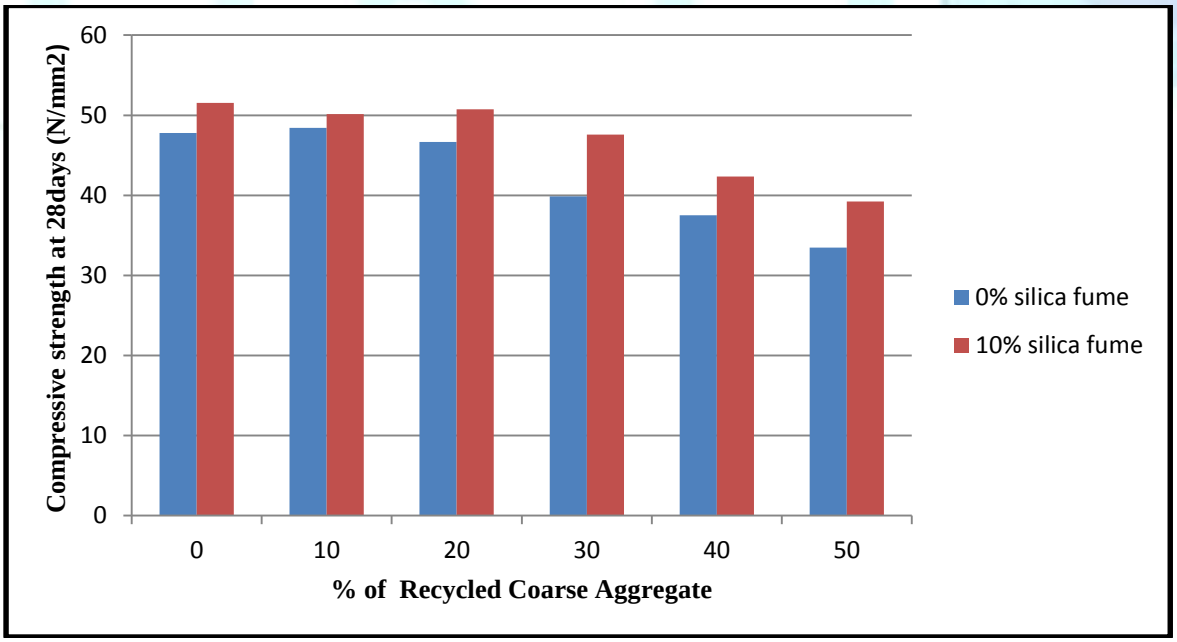

Figure 4: Effect of recycled coarse aggregate on compressive strength of concrete at 28days

4.4. SPLIT TENSILE STRENGTH

The results of Split Tensile strength at 28 days were presented in Table 5. The cylinders were tested using Compression Testing Machine (CTM) of capacity 2000KN. The below graphical representation shows that there was a considerable decrease in the split tensile strength of concrete with increase in the recycled coarse aggregate. The result shows that the replacement of silica fume by 10% by weight of cement may increase the tensile strength of concrete up to 10% to 20% for all the mixes incorporating silica fume. From Figure 5 it is noted that the split tensile strength at 28 days were gradually remains the same up to 20% replacement of recycled coarse aggregate. The maximum increase in split tensile strength is observed at 10% replacement of silica fume and the improvement in the tensile strength of concrete is due to the pozzolanic nature of the silica fume.

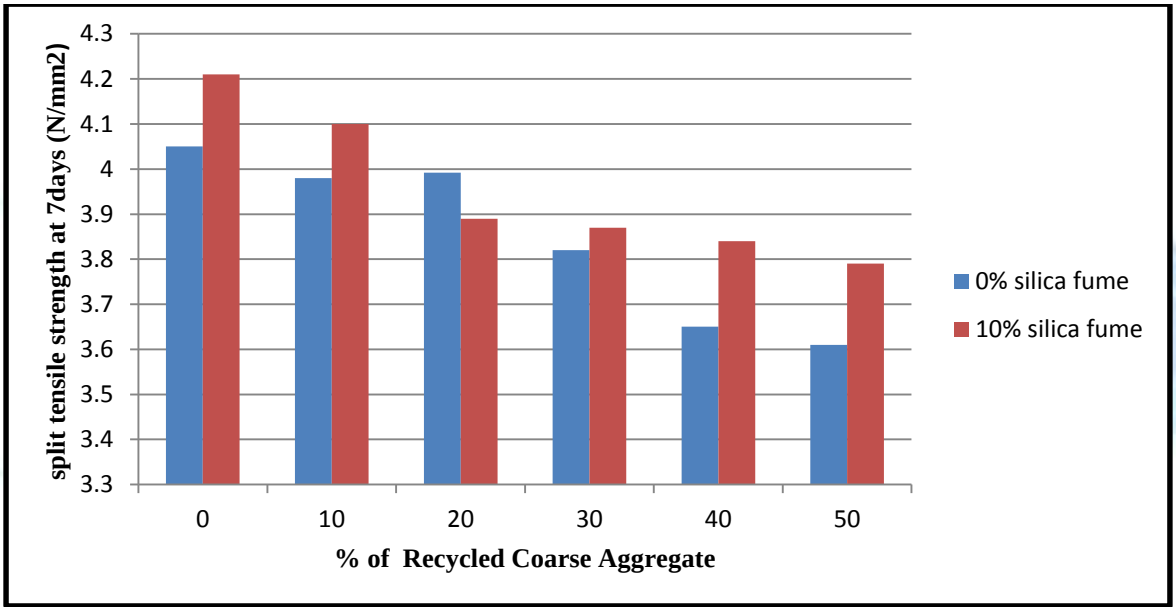

Figure 5: Effect of recycled coarse aggregate on Split tensile strength of concrete at 28days

V. CONCLUSIONS

Studies on waste construction materials are more important that the quantity of waste materials is gradually increasing day by day. From the present investigation it was found that the recycled coarse aggregates have more impact on physical and mechanical properties of concrete. As the percentage of recycled coarse aggregate is increased, the strength of the concrete gets decreased. From the results, the following conclusions were derived:

- It is clear that there is a possibility to use upto 30% recycled coarse aggregate concrete in structural construction and in addition of optimum level of silica fume may increase the possibility of using recycled coarse aggregate.

- The water absorption percentage increases upto 24% as the percentage of recycled aggregate replacement increases.
- Upto 20% replacement of recycled aggregate results in an increase of compressive and split tensile strength of concrete when compared with the reference mix.
- Beyond 30% replacement of recycled aggregate there was a decrease in strength values of concrete.
- Addition of silica fume on recycled aggregate concrete decreases the water absorption by 20% and the compressive strength and split tensile strength had increased up to 10% - 20% in all mixes of concrete.
- It is finally concluded that the recycled aggregates may be used upto 30% and sometimes beyond 30% with the addition of silica fume.

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