International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental Analysis of HPC with Recycled Aggregate

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ABSTRACT-

Increase in demand and decrease in supply of aggregates for the production of concrete, result in the need to identify new sources of aggregates. Recycled concrete aggregate is used for 40% of fine aggregate and natural sand is retained for the remaining part. High Performance concrete (HPC) of M60 Grade is attempted here with two types of admixtures i.e. silica fume and fumed silica. In this thesis, investigations were carried out on mechanical properties such as compressive strength, splitting tensile strength, flexural of M60 grade of HPC mixes with different replacement levels of cement by silica fume or fumed silica. The results of these investigations demonstrate the superior mechanical and durability characteristics of silica fume and fumed silica based concrete mixes. Based on the results obtained, the replacement of cement with 15% of silica fume and 1% of fumed silica which yields superior mechanical and durability characteristics was arrived at. The details of the investigations along with the results are presented in this thesis.

Keyword: ***HPC, Compressive Strength, Split Tensile, Flexural Strength, Fumed Silica, Silica Fumes.***

I. Introduction

Concrete is the most extensively used material in civil engineering and is the primary component in most infrastructures. In the foreseeable future, there seems to be no alternative to concrete as a construction material. Although strength of concrete is most important, it is also necessary that the concrete is durable, workable and provide a good service life. For example, in prestressed concrete bridges, the concrete should have not only high strength but also limited shrinkage and creep properties. For bridges, offshore structures, highway and airport pavements and machine foundations, concrete should possess high fatigue strength. For nuclear containers exposed to very high temperatures, the concrete must have high resistance to thermal cracking. Increase in demand and decrease in supply of aggregates for the production of concrete results in the need to identify new sources of aggregates. Construction materials are increasingly judged by their ecological characteristics. Concrete recycling gains importance because it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete. The principle of sustainable construction development requires prudent use of natural resources and maximum recycling of construction wastes through research and development work. The use of recycled aggregate in concrete construction is one such potential outlet.

II. Objective

The scope of the present work includes the following:

1. To determine the suitability of recycled concrete aggregate with respect to strength and durability.

2 To determine the optimum level of replacement of natural sand with recycled concrete aggregate.

3 To determine the strength of high-performance concrete containing mineral admixtures.

4 To conduct durability studies on high performance concrete with mineral admixtures.

5 To determine the toughness characteristics of high-performance concrete with mineral admixtures.

III. Experimental work

Materials:

1. Ordinary Portland Cement, 53 Grade conforming to BIS: 12269-1987. The results of the tests on cement sample are listed in Table 3.1

2. Silica fume in dry densified form obtained from ELKEM INDIA (P) LTD., MUMBAI conforming to ASTM C 1240. The properties are given in Table 3.2.

3. Fumed silica in dry densified form obtained from CABOT SANMAR LIMITED, Mettur Dam – Tamilnadu. The properties are given in Table 3.3.

4. Superplasticizer (chemical admixture) based on sulphonated naphthalene formaldehyde condensate - CONPLAST SP 430 complies with BIS: 9103-1999 and ASTM C 494 (1992). The Properties of the super plasticizer are given in Table 3.4.

5. Locally available quarry and crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per Table 2 of BIS: 383- 1970 with specific gravity 2.80 and fineness modulus 6.70 as coarse aggregates. The aggregates were tested as per the procedure given in BIS: 2386-1963 and the results are given in Table 3.5. The sieve analysis of coarse aggregate sample is also given in Table 3.6.

6. Locally available river sand conforming to Grading Zone II of Table 4 of BIS: 383-1970 with specific gravity 2.40 and fineness modulus 2.95 as fine aggregates.

7. Recycled concrete aggregate obtained from laboratory cast concrete with specific gravity 2.50 and fineness modulus 6.45. The sources of recycled coarse aggregate are given in Table 3.7.

8. Locally available drinking water is used for concreting and curing.

Compressive Strength Test:

Compressive strength was calculated through proper procedure with cube size 150*150*150 mm and is cured for 3, 7, 14 and 28 days before testing.

Flexural Strength Test

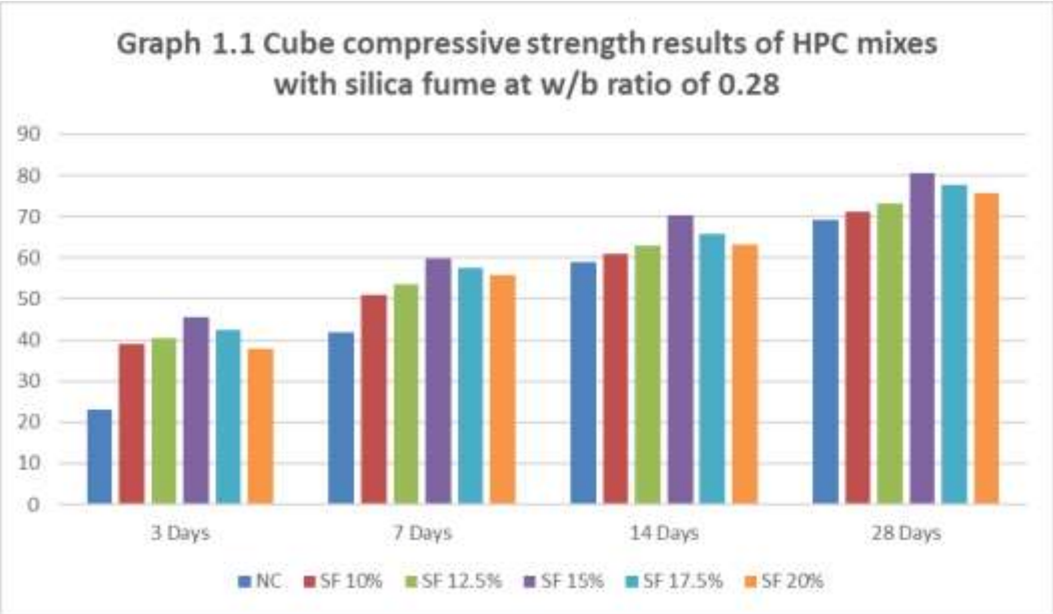
To determine the Flexural Strength of Concrete Test Specimen Beam of size 15 x 15x 70 cm (when size of aggregate is less than 38 mm) or of size 10 x 10 x 50 cm (when size of aggregate is less than 19 mm) shall be made.

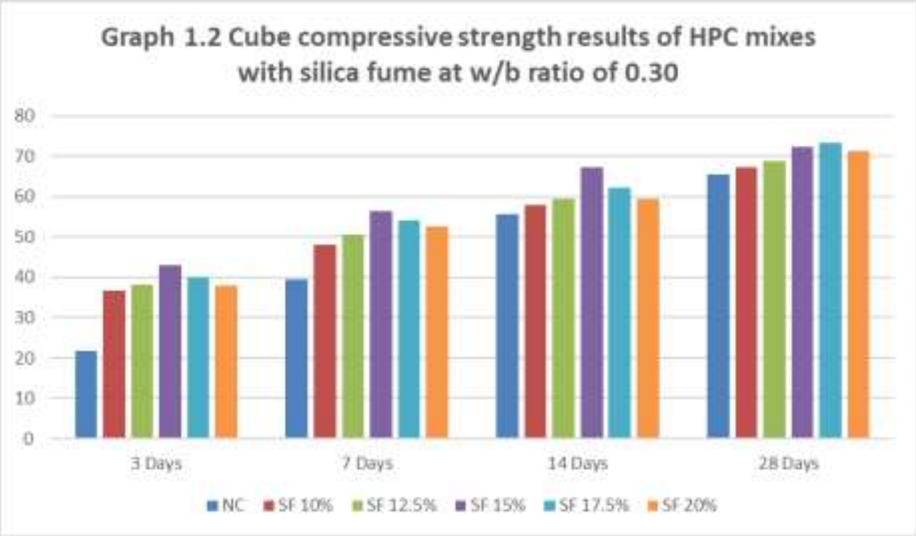
Split Tensile Strength Test

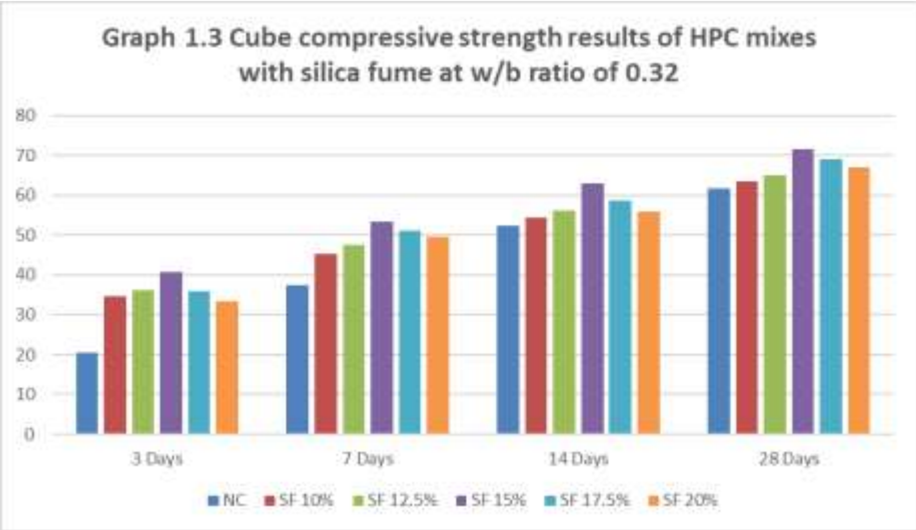
The cylindrical mould shell is of metal, 3mm thick. The mean internal diameter of the mould is 15 cm and the height is 30 cm.

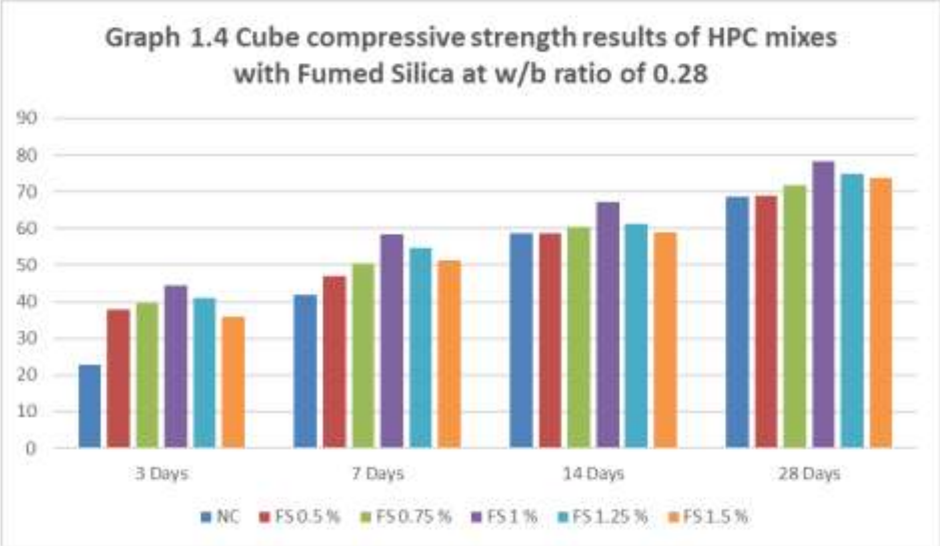
IV. Results & Discussion

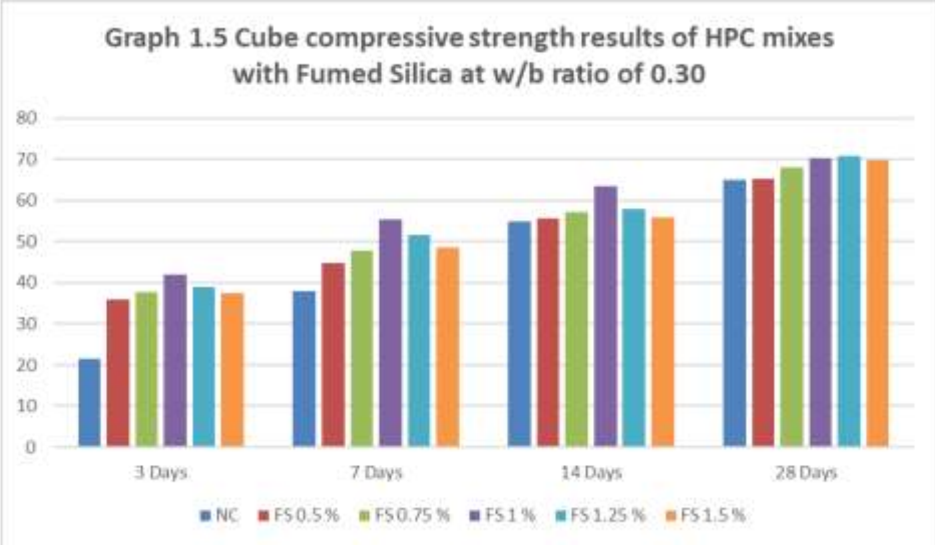
Compressive Strength Test:

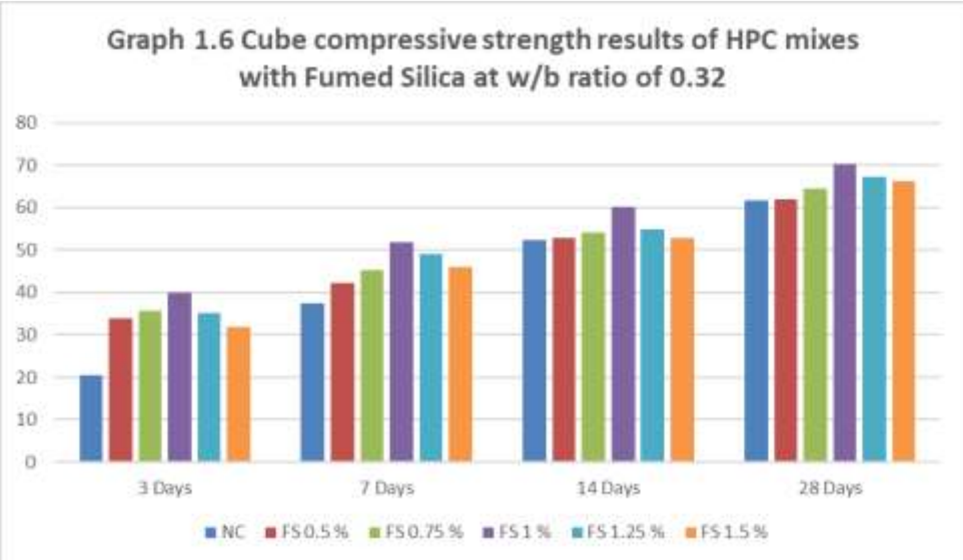



Graph 1.2 Cube compressive strength results of HPC mixes with silica fume at w/b ratio of 0.30
80
70
60
50
40
30
20
10
0
3 Days
7 Days
14 Days
28 Days
NC
SF 10%
SF 12.5%
SF 15%
SF 17.5%
SF 20%

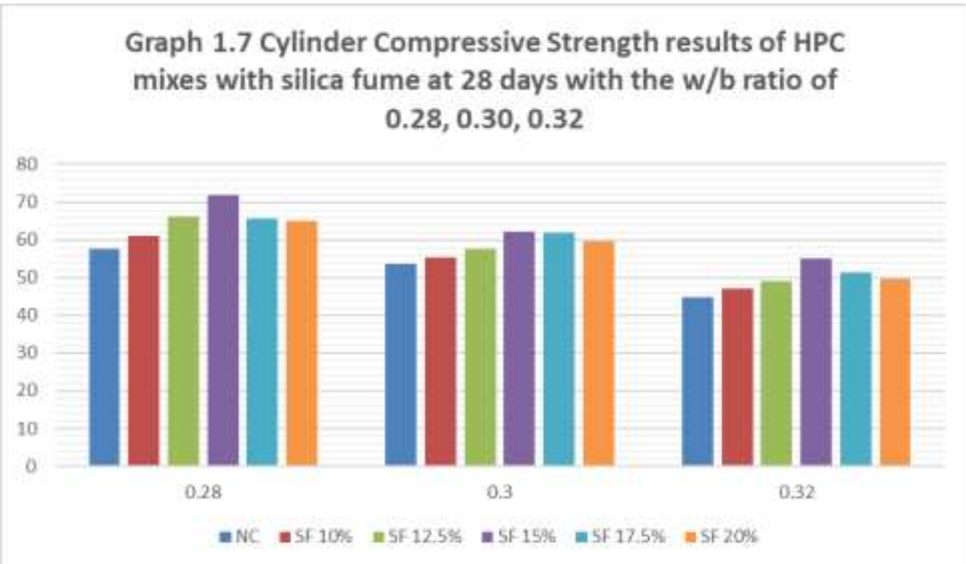

Graph 1.3 Cube compressive strength results of HPC mixes with silica fume at w/b ratio of 0.32
80
70
60
50
40
30
20
10
0
3 Days
7 Days
14 Days
28 Days
NC
SF 10%
SF 12.5%
SF 15%
SF 17.5%
SF 20%

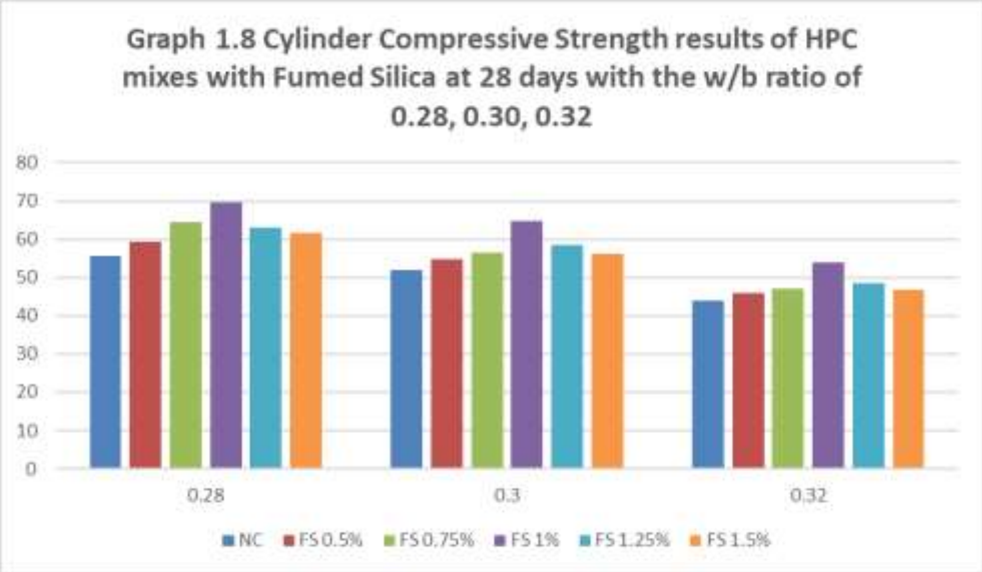

Graph 1.4 Cube compressive strength results of HPC mixes with Fumed Silica at w/b ratio of 0.28
90
80
70
60
50
40
30
20
10
0
3 Days
7 Days
14 Days
28 Days
NC
FS 0.5 %
FS 0.75 %
FS 1 %
FS 1.25 %
FS 1.5 %



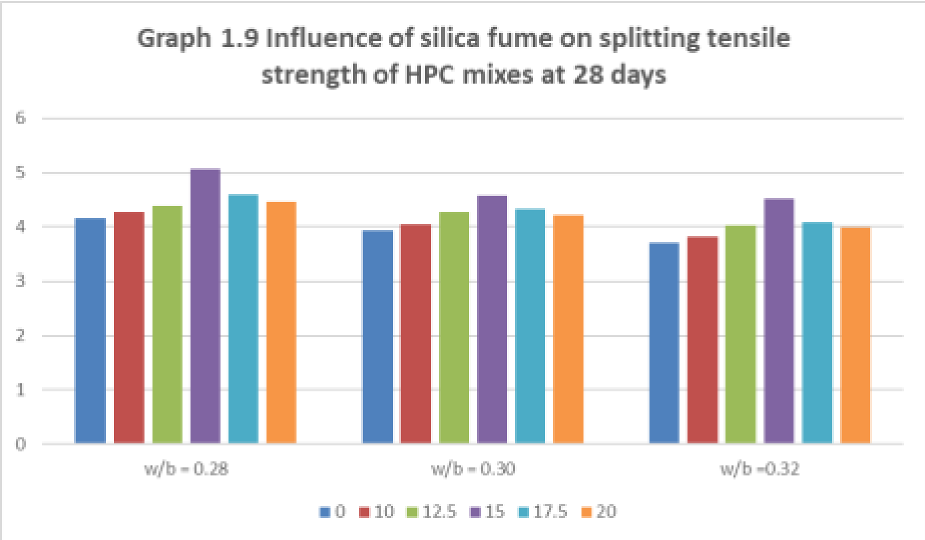


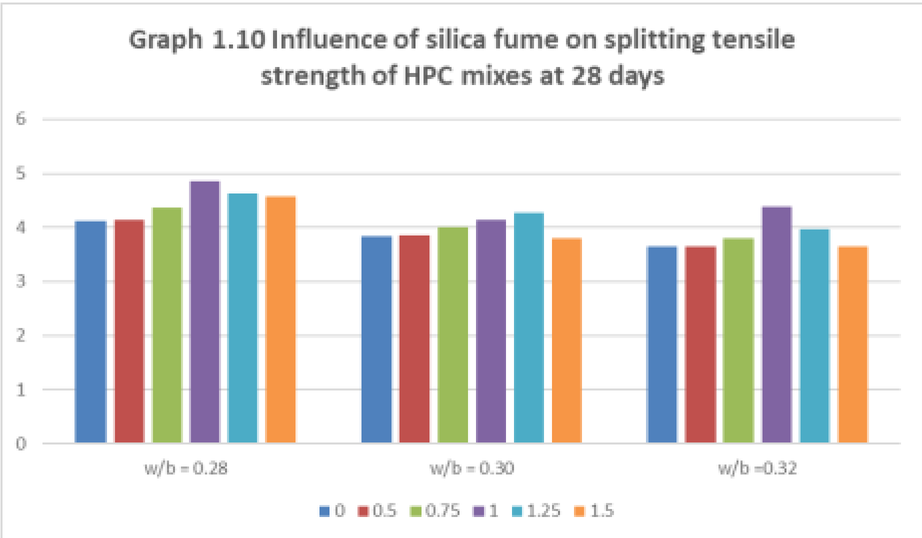
Cylinder Compressive Strength Test:



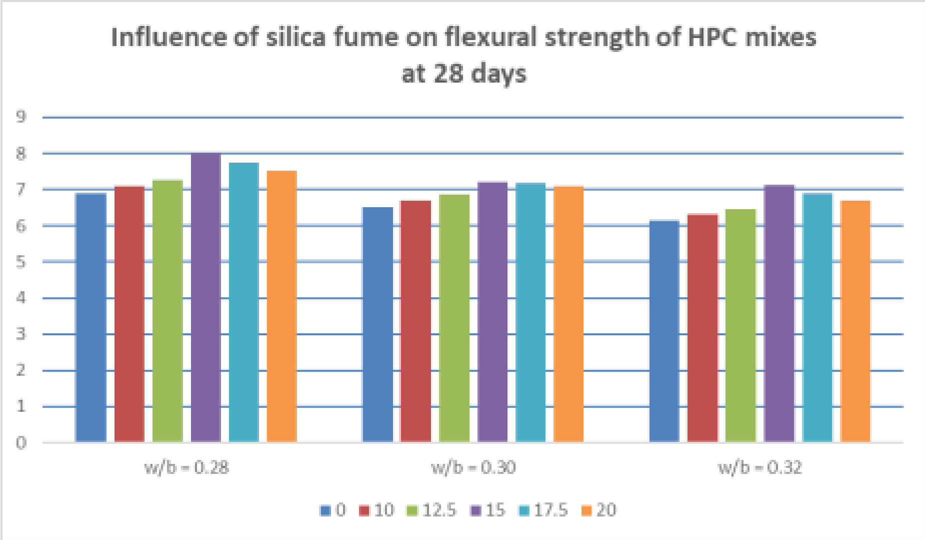


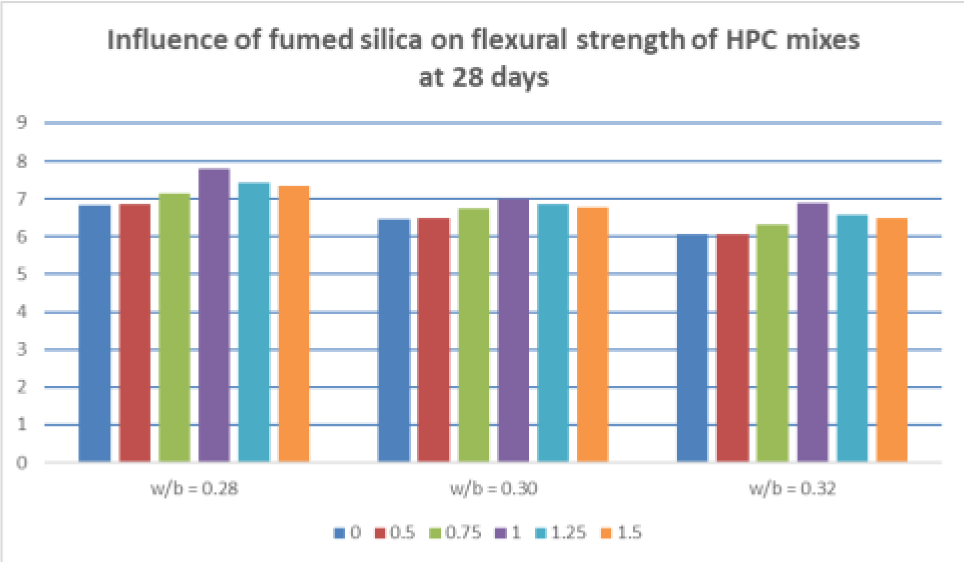
Split Tensile Strength Test:





Split Tensile Strength Test:





V. Conclusion

This study shows that RCA (Recycled Concrete Aggregate) in concrete can provide any technical benefits and it would also be fair to say provide many environmental and expected cost benefits. The study has shown that, regardless of original concrete type or strength, recycled good quality aggregates can be produced with plant similar to that used for the production of crushed – rock aggregates. Clearly, this information could encourage demolition contractors to direct demolished debris to the production of RCA for using new concrete, while reducing disposal to land fill.

Workability

The workability of concrete as measured from slump and compaction factor decreases as percentage of silica fume and fumed silica in concrete increases, whereas for Vee-bee degree increases for all w/b ratios. This is not only due to the fact that as the percentage of silica fume and fumed silica increases the water available in the system decreases, thus affecting the workability, but also due to the presence of high pozzolanic reactive nature of silica fume and fumed silica with liberated calcium hydroxide.

Cube Compressive Strength

At the age of 3, 7, 14, 28 days, the compressive strength of HPC mixes containing silica fume and fumed silica was more than that of mixes without silica fume and fumed silica. The 7-day and 14-day compressive strength of the HPC mixes was 60 to 78 and 85 to 92 percent of 28 days compressive strength respectively. This indicates that addition of silica fume and fumed silica as the partial replacement of cement causes early strength. There was an increase of only 5 to7 MPa and 2 to 6 MPa in the compressive strength between 28 days and 90 days for concrete mixes without silica fume and fumed silica respectively, while this increase was in the range of 10 MPa to 16 MPa and 10 to 13 MPa for HPC mixes containing silica fume and fume silica. This could be advantageously used for design of structures such as bridge piers, abutment walls and other mass concrete structural elements where early strength is not a criterion.

Cylinder Compressive Strength

The optimum replacement of cement by silica fume and fumed silica for HPC mixes was found to be 15 and 1 percent respectively for achieving maximum cylinder compressive strength at the age of 28 days at all w/b ratios.

The ratio between cylinder and cube compressive strength was found to be 0.89 at the age of 28 days.

Splitting Tensile Strength

The optimum replacement of cement by silica fume and fumed silica for HPC was found to be 15 and 1 percent respectively for achieving maximum splitting tensile strength at the age of 28 days at all w/b ratios. The tensile strength increases along with increase in compressive strength The tensile strength of HPC is 6 percent of cube compressive strength.

Flexural Strength

The optimum replacement of cement by silica fume and fumed silica for HPC was found to be 15 and 1 percent respectively for achieving maximum value of flexural strength at the age of 28 days at all w/b ratios.

The flexural strength increases along with increase in compressive strength. The flexural strength of HPC is 9 to10 percent of cube compressive strength.

The flexural strength of concrete at the age of 28 days was higher than the value calculated by the expression 0.7 ck as specified in BIS:456- 2000 The code BIS:456-2000 underestimates the value of flexural strength of silica fume and fumed silica -based HPC.

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