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Micro Silica as Partial Replacement of Cement in Concrete

Lins Paul Kuriakose[1], Ann Mariya Baby[2], Arif Ali[3], Muhammed P A[4] , Sandhra Sibi[5]

[1]Assistant professor,Department of Civil Engineering Viswajyothi College Of Engineering and Technology, Vazhakulam, Kerala, India
[2,3,4,5] UG scholars Department of Civil Engineering, Viswajyothi College Of Engineering and Technology,Vazhakulam, Kerala, India

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Abstract –*Concrete that has been treated with silica fumes is flowable in nature but still cohesive, producing high early and later age strength as well as resistance to hostile environments. This investigation explores the characteristics of silica fume and how they affect the characteristics of recently-poured concrete. The strength properties of concrete have been investigated through the partial replacement of cement with silica fume. Researchers looked at the strength characteristics of concrete without any partial replacement. Then, using cubes, cylinders, and beams cast in silica fume and tested using a compression testing machine (CTM), strength parameters were investigated. For cube, cylinder, and beam construction, silica fume was utilized to replace 5% to 15% of the cement by weight at increments of 2.5%. The results demonstrated that the compressive strength of the cube and split tensile strength of the cylinder were significantly affected by partially replacing cement with silica fume. The ideal value of compressive strength will be attained at 12.5% replacement. The strength of concrete increases quickly as the silica fume level increases.*

***Key Words**: Silica fume, compressive strength, splitting tensile strength, flexural strength.*

1.INTRODUCTION

1.1 General

Concrete is the most important engineering material, and adding other materials can change the properties of concrete. Micro Silica is a pozzolanic substance that has been used successfully all over the world since 1900 and is environmentally stable. It is an industrial by-product of the ferro-alloy and high purity quartz industries. A mineral additive known as micro silica is made up of small, solid silicon dioxide (SiO2) spheres. Nearly all of micro silica particles have a diameter of less than 1 micron (0.00004 inch), which is 50 to 100 times smaller than typical cement or fly ash particles. Fine amorphous silica is known as micro silica or silica fume. The most crucial component of an engineering design is concrete. Pozzolanic portions are added to concrete to boost its mechanical strength and durability because the silica in these materials blends with the calcium hydroxide generated during cement hydration to yield more calcium silicate hydrate (C-S-H).

1.2 Objectives

a) To evaluate the workability of concrete that has been 0%, 10%, 12.5%, and 15% partially replaced with micro silica.

b) To determine the optimum percentage of micro silica in conventional concrete.

c) To ascertain the flexural, split tensile, and compressive strengths of concrete using several substitutions of micro silica.

2.METHODOLOGY

The methodology adopted comprised of both preliminary and experimental investigations:

a) Literature review : The journals related to the topic are referred and collected. It helps to understand various aspects of the project and lead the progress of the project

b) Material collection : Cement, fine aggregate, coarse aggregate of required quantity is collected from the market. Micro silica is collected from ferro-alloy industry

c) Preliminary test : Specific gravity, setting time and consistency of cement are determined. Gradation bulk density and specific gravity of sand and micro silica are determined. Gradation and specific gravity of coarse aggregate is also found.

d) Casting of test specimen : Workability is tested using slump test. Mix proportioning is carried out for M 30 concrete. Components are mixed in required proportions and specimens are casted as cubes, cylinders and beam.

e) Curing : The specimens are cured in a curing tank for 28 days.

f) Specimen testing : The cube specimens are tested to determine compressive strength, the cylinder specimens for split tensile strength and beams for flexural strength.

g) Comparison and analysis of result : The value of different strength properties of concrete

partially replaced with micro silica is compared with that of traditional concrete. The result obtained is analysed to find optimum percentage of replacement.

h) Conclusion and report : The result obtained from the experiment are summarized and the influence is noted. A detailed report is prepared based on the observations

3. MATERIALS AND METHODS

3.1. Micro Silica

Silica fume, a crystalline variant of silicon dioxide, is additionally recognised as micro silica. It is a byproduct generated when quartz, limestone, and iron are used to produce silicon and ferro-silica. It comprises of mostly amorphous SiO2 (82%–96%) and very small, sphere-shaped particles (with a maximum dimension of less than 1 m).

The following tests are conducted on coarse micro silica and results are as follows

a. Specific gravity – 2.71

3.2. Cement

For this work 53 grade Ordinary Portland Cement is used. As per IS 12269:1987 following tests were conducted on cement and results are as follows

a. Standard consistency – 34 %

b. Initial setting time – 60 minutes

c. Specific gravity – 3.12

3.3. Fine aggregate

M sand is used for conducting the test. As per IS 383:1970 following tests are conducted on fine aggregate and results are as follows

a. Sieve analysis – Well graded sand

b. Specific gravity – 2.54

c. Bulk density – 1574 kg/m^3

3.4. Coarse aggregate

Stones from local quarry is used. As per IS 383:1970 following tests are conducted on coarse aggregate and results are as follows

b. Specific gravity – 2.73

c. Bulk density – 1620 kg/m^3

3.5. Concrete

Workability tests are conducted on concrete and observed results are as follows

a. Slump cone test – 40 mm

b. Vee Bee test – 7 sec

c. Compaction factor test – 0.78

3.6. Mix design details

Mix proportion – 1 : 2.53 : 3.26
Quantity of materials for 1 m^3 of concrete (M30 with w/c 0.44)
Weight of cement required = 333.79 kg
Weight of fine aggregate required = 844.5 kg
Weight of coarse aggregate required = 1088.17 kg
Weight of water required = 133.52 kg

Table 1: Preparation of specimen

Details	Cube	Cylinder	Beam
0 %	3	3	2
10 %	3	3	2
12.5 %	3	3	2
15 %	3	3	2
Total number	12	12	8
Size (cm)	Side : 15 cm	Height : 30cm Diameter : 15 cm	Side : 10 cm Height : 15 cm

Figure 1. Concrete mixing

Figure 2. Vibrating the concrete specimen

Figure 3. Specimen preparation

4. RESULT

5.1 Compressive strength test

It is a mechanical test which assesses how much compressive load concrete will tolerate before collapsing. It was a compression testing machine that was used.

Table 2 : Compressive strength test result

Mix (%)	Compressive strength after 28 days $(\frac{N}{mm2})$			Average compressive strength $(\frac{N}{mm2})$
	Specimen 1	Specimen 2	Specimen 3	
0	30	33	31	31.33
10	33.77	29.77	31.22	31.58
12.5	34.66	33.77	33.33	33.92
15	28.66	27.11	29.2	28.32

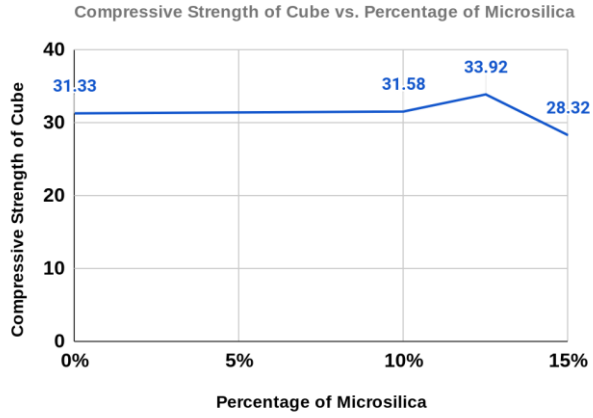

Figure 4 : Graph of compressive strength v/s percentage of micro silica

5.2 Splitting tensile test

It is a deceptive method of assessing the concrete's tensile strength.

Table 3 : Split tensile strength test result

Mix (%)	Split tensile strength after 28 days $(\frac{N}{mm2})$			Average split tensile strength $(\frac{N}{mm2})$
	Specimen 1	Specimen 2	Specimen 3	
0	2.39	2.22	2.13	2.24
10	2.12	2.12	2.26	2.16
12.5	2.4	2.38	2.36	2.38
15	1.97	2.01	1.98	1.99

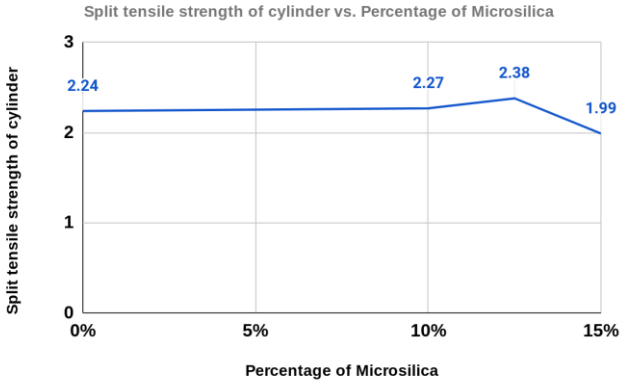

Figure 5 : Graph of split tensile strength v/s percentage of micro silica

5.3 Flexural strength test

The flexural strength is the stress before failure in bending. It matches or exceeds the failure stress in tension.

Table 4 : Flexural strength test result

Mix (%)	Flexural strength after 28 days $(\frac{N}{mm2})$			Average flexural strength $(\frac{N}{mm2})$
	Specimen 1	Specimen 2	Specimen 3	
0	11.75	11.3	11.4	11.48
10	12.2	12.4	11.54	12.04
12.5	14	13.2	13	13.4
15	12.2	13	12.5	12.56

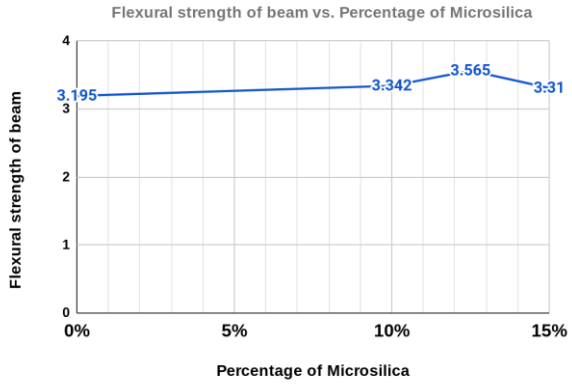

Figure 6: Graph of flexural strength v/s percentage of micro silica

6. CONCLUSION

Compressive strength: The compressive strength of the concrete cube increases when silica fumes are added in a 10% concentration. Adding 12.5 % of silica again can increase its compressive strength. Thus optimum strength of concrete is obtained at 12.5 % cement replacement by silica.

Split tensile strength: The concrete's split tensile strength can be increased by 10% silica fumes. Concrete reaches its peak strength when silica replaces cement by 12.5%.

Flexural strength: Flexural strength rises as micro silica content rises, reaching its peak at 12.5%.

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8. BIOGRAPHIES

Lins Paul Kuriakose
Assistant professor
Department of Civil Engineering
Viswajyothi College of Engineering and Technology, Vazhakulam, Kerala

Arif Ali
4th year student, Civil engineering
Viswajyothi College of Engineering and Technology, kerala

Ann Mariya Baby
4th year student, Civil engineering
Viswajyothi College of Engineering and Technology, kerala

Muhammed P A
4th year student,Civil engineering
Viswajyothi College of Engineering and Technology, kerala

Sandhra Sibi
4th year student,Civil engineering
Viswajyothi College of Engineering and Technology, kerala