Micro Silica Modified Engineered Cementitious Material for Concrete

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Abstract: **Extensively researched work for quite a long time additionally in progress all through the globe in concrete technology innovation in discovering alternative materials which can partially replace ordinary Portland concrete (OPC) and which can likewise meet the necessities of strength and durability execution of modern industrial by-products like Micro-silica (M-S), ground granulated blast furnace slag, fly ash, metakaolin, rice husk and so forth presently named as complimentary cementitious materials (CCM) encouraging. The Present experimental test is completed in the enhancement of a Ternary Blended Cementitious system dependent on Ordinary Portland Cement (OPC)/GGBS/M-S for the improvement of Ternary Blended Concrete. In this current investigation study strength properties Compressive strength, split tensile strength, and flexural strength of M50 grades of cement concrete with the utilization of micro-silica (0%, 2%,4%, 6%, 8%, and 10%) as partial replacement of cement concrete was studied.**

Keywords

[Keywords: Micro-silica(M-S); complimentary cementitious materials (CCM); ordinary Portland cement (OPC)); ground granulated blast furnace slag (GGBS); Reinforced Cement Concrete (RCC); Weight % (wt.%); Nano-silica (N-S); perlite powder (PP) water/cementitious materials (W/CM);]

I. INTRODUCTION

Concrete is the most largely used development material on the planet. In recent years, specialists have focused on the improvement of concrete quality regarding its mechanical and durability properties. These can be accomplished by the use of strengthening cementitious materials. M-S is made out of silicon dioxide (SiO_2), gathered from silicon metal and ferrosilicon. M-S will be reacted with the calcium hydroxide from the concrete, which will form a greater amount of the calcium silicate hydrate, expanding the strength of the concrete. Utilizing M-S will likewise expand the durability of the concrete. It has a high substance of silicon dioxide (SiO_2) and comprises of exceptionally little circular particles. Along these lines, it has a decent hairlike filling impact and high pozzolanic movement, which can successfully improve the pore structure of cement. Additionally, M-S likewise can improve the tensile strength and compressive strength as well as the frost resistance of concrete.

In recent years, various researches show that the replacement of M-S to the cement is used to obtain high strength and corrosion resistance concrete. The mechanical properties and frost resistance of Reinforced Cement Concrete (RCC) with the new admixtures of limestone powder and M-S explored at specified ages. The experimental study focused on the mechanical properties of each group at 7d, 28d, and 90d [Shen et al. 2020] including compressive strength, splitting tensile strength, elastic modulus, also their anti-cracking performance investigated. Besides, the miniature instrument of each gathering was dissected from a microeconomic view, to recognize the large-scale execution of RCC.

This paper provides experimental data on the response of materials that can partially replace Ordinary Portland Cement (OPC) and which can also meet the requirements of strength and durability performance of industrial by M-S.

II. LITERATURE REVIEW

Bagherzadeh et al studied the effect of incorporating different sizes of silica microparticles (for example with Mesh size of 100, 200, 400, and 600 wt.%) and their hybrids on the properties of the epoxy composite adhesives was investigated. To determine the performance of the M-S based epoxy adhesives, their mechanical (for example the compressive, tensile and flexural) properties and attachment to cement and steel bar (for example pullout test) were assessed. In the interim, the impact of surface mugginess of M-S particles on the mechanical properties of the epoxy concrete was evaluated. From this point forward, SiO_2 and $CaCO_3$ nano particles at 1, 3 and 5 wt.% was applied to the M-S based composites and the mechanical and pull-out properties were resolved. Results indicated that dampness content was immaterial in M-S particles however it caused a 7, 40 and 25% decrease in the tensile modulus, flexural strength, and flexural modulus of the epoxy samples utilizing M-S particles with work 600 in epoxy folio caused the best exhibitions in the epoxy composites and improved 266, 205, 60 and 102% the compressive strength, compressive modulus, tensile strength, and flexural strength, respectively. Hybridizing M-S particles with various sizes significantly affected the adhesive mechanical properties. Consolidating $CaCO_3$ to the composites containing M-S just improved compressive strength but small affected different properties. Finally, using nano SiO_2 along with M-S due to its incompatibility with epoxy resin caused a considerable diminution in the mechanical and bonding properties especially at higher loading contents.

Esfandiari et al evaluated the short and long terms mechanical properties of Self-Compacting Concrete (SCC) with a lime-cement binder, Micro-Silica (M-S), perlite Powder (PP), and Micro-silica perlite-powder (PP) the point of the current examination was to research the impacts of various measures of added substances on the new and mechanical properties of SCC. Likewise, in this exploration cement-lime binder was supplanted by M-S, PP, and MS-PP at 0%, 5%, 10% 15%, and 20%, individually. The ideal rate was 17% for SF, 6% for PP and 6% for MS-PP on 28th and 90 days to acquire the most extreme compressive strength. The outcomes demonstrated that water ingestion, dry thickness, of the 28 days compressive Strength expanded with an expansion in M-S (MS) content. The substance of PP and MS-PP substitution additionally impacted the subsequent SCC, but the latter had a better effect on the concrete. The highest compressive strength of SCC was seen at 17%, 6%, and 6% for MS, PP, and MS-PP, individually (on days 90). At the point when 10% of lime powder was included rather than cement, the ideal utilization of M-S dropped to underneath 20%. The optimum usage of M-S normal concrete is above 20%.

Li et al investigated the combined effects of M-S and N-S on the compressive behavior of concrete. Micro-Silica (M-S) can improve the strength and durability of concrete and the addition of nano-silica (N-S) can likewise improve certain properties of concrete. However, systematic research is still needed to exploit the benefits of the advantages of consolidated use of M-S and N-S, and all the more explicitly, to assess cementing efficiencies and synergistic effect. In this examination, a test program was dispatched to research the joined impacts of M-S and N-S on the compressive conduct of concrete. Mixes water/cementitious materials (W/CM) proportion, M-S substance, and NS content yet comparable usefulness were created for testing. It was discovered that NS has a lot higher superplasticizer (SP) demand and cementing efficiency than M-S. Nevertheless, at the same strength, the SP demand of (M-S, N-S) is not higher than that of pure cement.

Jordi Massana et al examined the effects of binary and ternary mixtures of N-S and M-S on the durability of High-Performance Self Compacting Concrete (HPSCC). Compressive strength at 28 days, quickened carbonation measures following 60 and 200 days of introduction to CO_2, protection from freeze-defrost cycles, and fine pull coefficient, were investigated. Also, microstructural characterization was carried out by Mercury Intrusion Porosimetry (MIP). Ten mixes were fabricated: one without additions as control, three with 2.5%, 5%, and 7.5% of NS, three more with 2.5%, 5%, and 7.5% of MS, and three utilizing the two admixtures, with 2.5%/2.5%, 5%/2.5% and 2.5%/5%, of N-S and M-S, respectively. The most noteworthy compressive strength is accomplished in the ternary more extensive molecule size circulation makes a low porosity, improves pressing thickness, diminishes water interest in correlation with combinations with a similar measure of absolute expansion utilizing just N-S, the permeable organization in blends with N-S included a more modest pore breadth to control, corresponding to the measure of N-S. In concretes with M-S, there was a lower total porosity with an average pore size similar to the reference concrete. In ternary blends, the permeable organization gave cement a more modest normal pore size and a more modest complete porosity. This created cement with high conservativeness and improved toughness properties, with lower slim assimilation and a lower defenselessness to carbonation and freeze-defrost cycles.

III. MATERIALS USED AND THEIR PROPERTIES

In this present investigation materials used are Cement, Fine aggregate, Coarse aggregate, Micro Silica.

3.1. Cement

The cement of Ordinary Portland Cement (OPC) of 43 Grade was used which satisfies the requirements of IS: 12269-1987. The cement used will be free from lumps. Cement will be bought from the same source throughout the research work. While storing cement, care will be taken to avoid possible content of moisture.

3.2. Fine Aggregate

Fine aggregate is regular sand that has been washed and sieved to eliminate particles bigger than 4.75mm. The locally available river sand passing 4.75mm sieve as per IS:383 (2016) will be used as a fine aggregate for this investigation.

3.3. Coarse Aggregate

Coarse aggregates are gravel which has been crushed, washed, and sieved so that the particles vary from 5 mm up to 50mm in size. Crushed broken stones that are retained on a 4.75mm sieve will be used as coarse aggregate for this investigation as per IS:383 (2016).

3.4. Water

Potable water will be used throughout to ensure that the water is reasonable free from impurities such as suspended solids, organic matter, and dissolved salts.

3.5. Micro silica

M-S is made out of silicon dioxide (SiO_2), collected from silicon metal and ferrosilicon. M-S will react with the calcium hydroxide from the cement, which will frame a greater amount of the Calcium silicate hydrate, increasing the strength of the concrete. Utilizing M-S will increase the durability of the concrete. Properties of M-S is shown in table 1.

Table 1: Properties of Micro Silica.

Parameter	Unit	QC Limit	Test Result
Appearance	-	Free Flowing Powder	Pass
Type	-	Densified Micro Silica	Complies
SiO2 (As per IS 1727-1967, RA2013)	%	>85	86.2
Loss on Ignition	%	2.0-4.0	3.1

Moisture Content	%	0.1-0.35	0.15
Particle Size	Microns	0.03-0.1	0.05
Retention in 45 microns	%	0.4-2.5	1.1
Dry bulk density	Kg/m3	500-700	615

IV. EFFECT OF MICRO SILICA ON THE MECHANICAL PROPERTIES – AN EXPERIMENTAL STUDY

4.1. Experimental program

The experimental program was intended to look at the mechanical properties i.e. compressive strength, split tensile strength, and flexural strength of high strength concrete with M50 evaluation of cement and with various substitution levels of ordinary Portland cement (43grade) with M-S (2%, 4%, 6%, 8%, and 10%).

4.2. Mix Proportions:

Concrete mixes were designed to a compressive strength of M50 grades with a water-cement ratio of 0.32 respectively as per IS code 10262-2019. In the cases, the cement was replaced with MS (2%, 4%, 6%, 8%, and 10%). Table 2 Mix proportion of M50 grade concrete.

Table 2: Properties of M-S.

S. No	Materials	Quantities in Kg/m3
1	Cement	450
2	Water	144
3	Fine aggregate	638
4	Coarse aggregate	1257
5	Water cement ratio	0.32

The Samples of standard cubes (100 mm X 100 mm X 100 mm) standard cylinders of (150 mm Día x 300 mm height) and standard beams of (100 mm x 100 mm x 500 mm) were cast with different rate substitutions of M-S.

4.3. Mechanical Properties:

4.3.1 Compressive Strength:

The compressive strength M50 grade concrete, MS concrete at 28 days is introduced in table 3. The consequences of compressive strength were introduced in Table 3 and figure 1. The test was done adjusting to IS 516-1959 to get the compressive strength of concrete at 7 days and 28 days. The cubes were tested in a Compression Testing Machine (CTM) of capacity. The compressive strength is up to 43.55 MPa and 67.66 MPa at 7 and 28 days. The greatest compressive strength is seen at a 4% substitution of M-S. There is a significant improvement in the compressive strength of concrete in view of the high pozzolanic nature of the M-S and its void filling capacity.

Table 3: Compressive Strength.

S.No	Replacement % of M-S	Compressive Strength in MPa	
		7 Days	28 Days
1	0	40.06	57.75
2	2	42.40	64.50
3	4	43.55	67.66
4	6	36.80	57.35
5	8	33.45	56.20
6	10	31.25	54.45

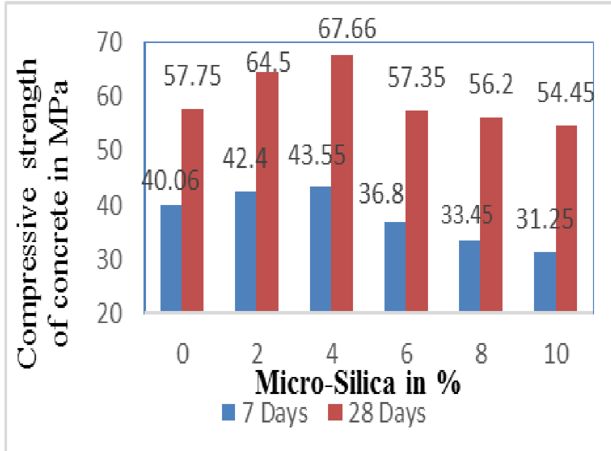

Figure 1: Compressive Strength at 7 days and 28 days.

4.3.2. Flexural Strength:

The results of the flexural strength of typical concrete and M-S replaced concrete was introduced in table 4 and figure 2. The test was done adjusting to IS 516-1959 to get the flexural strength of concrete at the time of 28 days. The cubes were tested utilizing the Universal Testing Machine (UTM). The greatest increment in flexural strength is seen as 5.56 MPa at 28 days when M-S is replaced by cement 4%. The flexural strength at the age of 28 days of M-S concrete continuously increased regarding traditional cement and arrived at a most extreme estimation of a 4% replacement level for M50 grades of concrete.

Table 4: Flexural Strength in MPa at 28 days.

S.No	Replacement % of M-S	Flexural strength in MPa at 28 days
1	0	4.17
2	2	5.08
3	4	5.56
4	6	3.98
5	8	3.77
6	10	3.40

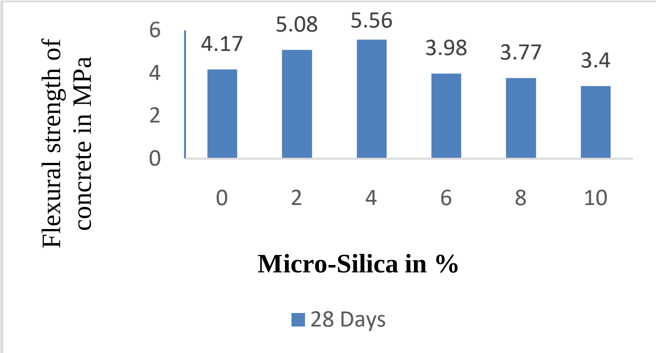

Figure 2: Flexural Strength of Concrete.

4.3.3. Split Tensile Strength:

The results of Split Tensile Strength were introduced in Table 5 and figure 3. The test was completed adjusting to IS 516-1959 to acquire split tensile strength of concrete at the age of 28 days. The cylinders were tested utilizing a Compression Testing Machine (CTM) of limit 2000 KN. The increase in strength is 5.82 MPa at age of 28 days. The greatest increment in split tensile strength is seen at a 4% substitution of M-S. The optimum 28-day split tensile strengths have been acquired in the scope of 4% M-S smolder substitution level, while the incentive for flexural strength went from 2% to 4%. Concrete blends were intended to a compressive strength of M50 grades with a water-concrete proportion of 0.32 separately according to IS code 10262-2019. In the cases, the concrete was supplanted with MS (2%, 4%, 6%, 8%, and 10%). Table 7 Mix extent of M50 grade concrete.

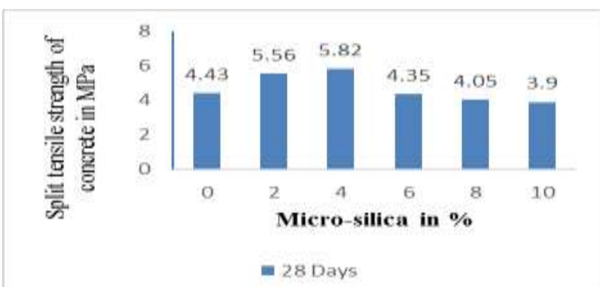

Figure3: Split Tensile strength at 28 days.

Table 5: Split Tensile strength in MPa at 28 days**.**

S.No	Replacement % of M-S	Split Tensile strength in MPa at 28 days
1	0	4.43
2	2	5.56
3	4	5.82
4	6	4.35
5	8	4.05
6	10	3.90

V. CONCLUSION AND FUTURE WORK

There is an overall increment in the mechanical properties of the concrete with the introduction of micro-silica. On experimental results, the following conclusions are drawn:

1. Mix design for M50 grade of concrete according to IS 10262:2019 and replacing the cement substance by various percentages as mentioned earlier for the mixed design impact of M-S is observed.
2. Concrete procured a superior pressing of its constituents due to very little particles of M-S and turns out to be more impermeable with strong the transition zone between aggregate and cement paste.
3. Compressive strength of concrete increased effectively with replacement of M-S and best result observed at 4% replacement of cement.
4. The flexure strength at the age of 28 days of M-S concrete increased in comparison to conventional concrete and arrived at the greatest replacement-level for M50 grades of concrete.
5. The most extreme increment in compressive strength, split tensile and flexural strength is 17.16%, 31.38%, and 33.33% respectively.

VI. FUTURE WORK

I. A lot of work has been done including the utilization of micro silica in concrete. Later on, the results of micro silica can be concentrated in detail. A detailed investigation of the microstructure at specific intervals can give a very good idea of thought regarding the reactions occurring in the concrete.

II. Further examination can be stretched out on different properties of concrete by changing the particle size of micro silica (SiO_2) and different grades of concrete.

Also, a similar investigation of deflection and cracking patterns can also be done for beam and slab utilizing micro silica.

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BIOGRAPHY

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