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Influence On Compressive Strength of Concrete On Addition of Micro Alumina Particles To Cement

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Abstract

In this experimental work, micro Alumina particles have been mixed in M 25 grade concrete with various percentages (by weight of cement) to know the effect of micro Alumina particles on concrete compressive strength. The percentages of micro Alumina particles range from 0% to 15% with an increment of 1%. Three specimens were cast and tested for each sample for 7 days compressive strength, and three specimens were cast and tested for 28 days compressive strength. The compressive strength test has been conducted after 7 days curing and 28 days curing. The specimens containing 4% of micro Alumina particles showed peak average compressive strength of 22.6N/mm at 7 days of age, which was 13% higher than the average compressive strength of controlled specimens at 7 days. The specimens containing 12% of micro Alumina particles showed a peak average compressive strength of 40.51N/mm at 28 days of age, 22.79% higher than the average compressive strength of controlled specimens at 28 days.

Keywords — *Addition, Cement, Concrete, Compressive Strength, Micro Alumina.*

I. INTRODUCTION

A. General Overview

Concrete is a homogeneous mixture of cement, fine aggregate, coarse aggregate, and water with very high compressive strength and very low tensile strength. Many substances can help achieve a higher compressive strength compared to conventional Concrete if they are added or partially or fully replaced with the basic ingredients of Concrete. Among those substances, the micro Alumina particle is one of the substances that help achieve a higher compressive strength concrete (by mixing in cement} compared to conventional Concrete for the same mix proportion. Various experimental studies have been carried out recently using different particle sizes of Alumina (i.e., nano size and micro size) in concrete mix and mortar mix to investigate Concrete's mechanical properties. The Alumina particle shows some extraordinary properties in nano size and micro size, which is beneficial for improving Concrete's mechanical properties. This is the main reason behind the researcher's interest in this field.

B. Objectives of Study

The objectives of this experimental study are as follows:

i) To find out the percentage of micro Alumina at which average peak compressive strength develops.

ii) To compare the average compressive strength of all samples and determine the reason behind the variation in average compressive strength.

iii) To know the cost difference between the production of controlled Concrete and Concrete contained micro Alumni particles.

C. Scope of Study

This experimental study's main focus area is to determine the increment or decrement in compressive strength of different concrete mixtures with different micro Alumina particle percentages. For the compressive strength test, sixteen cube samples have been cast. For each sample, three cube specimens have been cast. The compressive strength test has been performed in CTM (Compression Testing Machine), having the capacity of 2000KN.

II. MATERIALS

Ordinary Portland cement, sand, coarse aggregate, micro Alumina particle, and water have been used for experimental work. The essential test has been performed for all the materials to confirm that material properties meet experimental work requirements and codal provisions.

A. Ordinary Portland Cement:

For this experimental work, "Maha" cement has been used as ordinary Portland cement. The cement grade is 53, based on laboratory test, and the test has been done as per IS 4031(Part 6):1988. This cement confirms to I.S. 8112:2013. This physical properties of cement obtained from laboratory test conforms to requirements against I.S. 269:2015.

B. Aggregate:

In this experimental work, crushed stone was used as coarse aggregate, and sand was used as fine aggregate. The aggregates were clean, dry, and free of any absorbed chemical. The maximum size of the coarse aggregate is 20mm, and the maximum particle size of sand is 4.75 mm. Sieve analysis of sand has been carried out to find the zone of sand. By sieve analysis, the sand has been confirmed to zone II as per I.S. 383:1970. Specific gravity test, Water absorption test, and bulk density test has been carried out for aggregates. The physical properties of aggregates were evaluated as per IS 2386 (Part3):1963.

C. Micro Alumina:

In this experimental work, micro Alumina particles have been used along with cement, aggregates, and water. Micro Alumina particle was in the form of powder. The color of the powder was white. The particle size of the micro alumina particle was in micron. So that it has a good specific surface area and the bulk density was also good. The physical properties of micro Alumina particles are given below.

1) Specific surface area- 70 m2/gram
2)Bulk density- 1050 kg/m3
3) Average particle size- 45±5 µm

D. Water

In this experimental work, potable water has used. The water was clean and free from suspended solids and other Impurities. The water quality has confirmed to IS 3025 (Part 22):1986 and IS 3025 (Part 23):1986

III. METHODOLOGY

A. Overview:

All the tests for raw materials were performed. The various percentage of micro Alumina particles which have to present in each sample was also determined. So that it came to know that how many cubes to be cast.

B. Research Planning:

For this experimental study, the following sequence of work has followed :

Preparation of molds
↓
Batching of materials
↓
Mixing of materials
↓
Casting of specimens
↓
Curing of specimens
↓
Testing of specimens
↓
Analysis of result
↓
Conclusion

C. Experimental Program

For 7 days, compressive strength 17 samples have taken. Similarly, for 28 days, compressive strength 17 samples has taken. For each sample, three cube specimens had casted. A total of 102 cube specimens had casted. The dimension of the cube specimens was 150mm x 150mm x 150mm.

For casting and testing of cube specimens, some steps given below have followed:

1) Preparation of Moulds:

For the casting of cube specimens, cast Iron molds have been used. The inner dimension of the mold is 150mm x 150mm x 150mm. For molds' preparation, at first, all molds were cleaned, and then bolts were tightened. With the help of a brush, oil was applied on the inner bottom surface and all molds' inner sidewalls.

2) Batching of Materials:

As per mix design proportion, cement, sand, coarse aggregate, and water were batched. The batching was done by weight. Micro Alumina particles were also batched by weight. The various percentage of Micro Alumina particles is taken as a percentage weight of cement.

3) Mixing of Materials :

The next step was mixing. The main purpose of mixing is to produce a homogeneous concrete mixture with any segregation and bleeding. For mixing cement, sand, coarse aggregate, water, and micro Alumina particles following steps has followed :

- At first, cement was taken in a tray. Then micro Alumina Particles poured into cement and mixed uniformly with the help of a trowel. (For controlled concrete micro Alumina particles were not mixed with cement)
- Then this mixture of poured into the sand and mixed uniformly with the help of a trowel.
- Then the cement-sand-micro Alumina Particles mixture poured into coarse aggregate and mixed uniformly with the help of a trowel.
- Then water was added to the dry mixture and mixed thoroughly.

4) Casting of Specimens:

- Placing – After mixing, the wet concrete mixture is poured into a prepared mold with a trowel's help. Molds were filled up to the topmost level.
- Compaction – To remove those air voids from fresh concrete table vibrator has used. Molds were filled with wet

concrete mixture place on the top of the table vibrator, and compaction was done 1 to 2 minutes. Again, wet concrete mixture poured into mold up to the topmost level, and compaction was done. This process is repeated 2 to 3 times.

- ❖ Finishing - After compaction, finishing was done on the Concrete's topmost surface with a trowel's help.

5) Curing of Specimens:

After 24 hours of casting, all the molds were unmoulded. Then all the cubes were placed in a water tank filled up with water. For 51 cube specimens curing had been done for 7 days. And for the rest, 51 cube specimens curing had been done for 28 days.

6) Testing of Specimens:

Testing of Fresh Concrete:

For fresh concrete slump test had performed. The test had performed as per guidelines of I.S. 1199:1959. For this test, the required apparatus is a slump cone (10cm top diameter, 20cm bottom diameter, and 30cm height), weighing machine, tray (small and big size), trowel, and tempering rod (16mm diameter and 600mm length). The required materials are cement, sand, coarse aggregate, water, and oil.

Testing of Hardened Concrete:

The compressive strength test was performed as per guidelines of I.S. 516:1959. The testing was performed in the compression testing machine (capacity 2000KN).

At first compressive strength, a test was conducted for 7 days of compressive strength. At first, cube specimens were extracted from the water tank and then dried in the laboratory room. When the surface of specimens became dry, then at one time, each specimen was placed in a compression testing machine. Then load was applied and increased gradually till a crack appeared on the specimen surface. When cracks have appeared on the specimen, the applied peak load was noted, and the load was removed. After that, the cracked specimen was dumped in the disposal area.

The 28 days compressive strength test was carried out similarly to 7 days compressive strength test. (Except curing has done for 28 days)

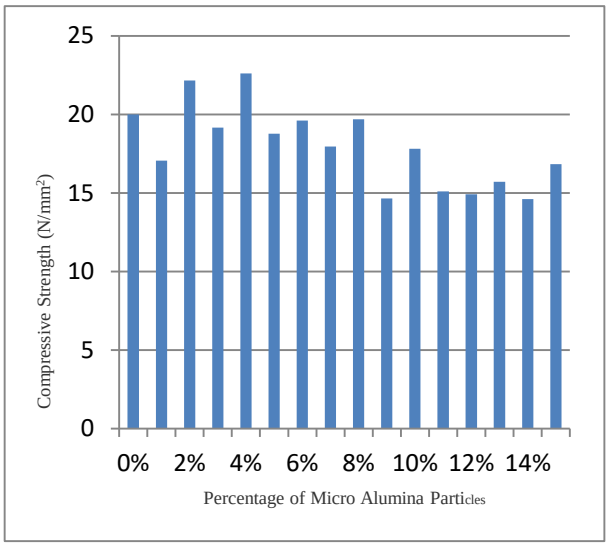
IV. RESULTS AND DISCUSSION

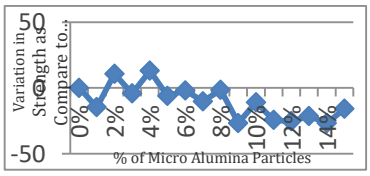
A. Test Results

1) Workability (Slump): The controlled concrete mix's workability has been recorded in the form of a slump, i.e., 96mm.

2) 7 Days Compressive Strength:

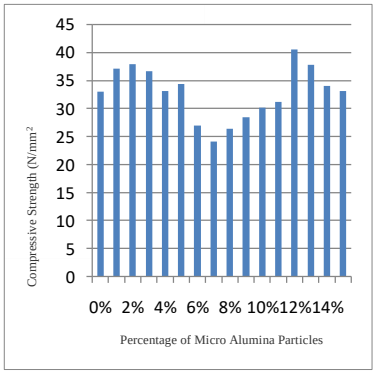
After 7 days of curing of specimens, a compressive strength test had conducted. From there following result has obtained:

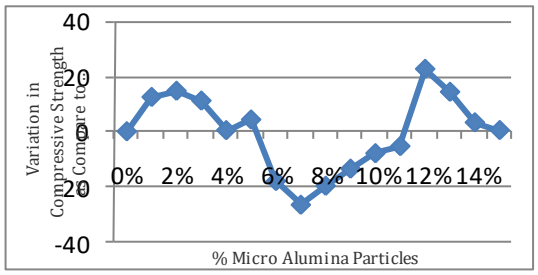




3) 28 Days Compressive Strength:

After 28 days of curing of specimens, a compressive strength test had conducted. From there following result has obtained:





B. Discussion:

For 7 days compressive strength test average compressive strength for the controlled concrete specimen is 20N/mm². The peak average compressive strength is obtained for a concrete specimen containing 4% micro Alumina particles as 22.60N/mm², which is 13% more than the average compressive strength of a controlled concrete specimen. The graph shows that up to 4% of micro Alumina particle's average compressive strength increases and then decreases significantly, up to 15% of micro Alumina Particles.

28 days compressive strength test average compressive strength for the controlled concrete specimen is 32.99N/mm². **The peak average compressive strength is obtained for a concrete specimen containing** 12% micro Alumina particles as 40.51N/mm², 22.79% more than the average compressive strength of a controlled concrete specimen. Graph 5.3 and Graph 5.4 show that the average compressive strength increases up to 2% of micro Alumina particles and decreases to 7% of micro Alumina particles. After then again starts to increase up to 12% of micro Alumina particles (peak average compressive strength) and then decreases up to 14% of micro Alumina particles and then increases a little up to 15% of micro Alumina Particles.

The main reason behind the improvement in compressive strength from 0% to 2% of micro Alumina particles is that micro Alumina particles react with Calcium Hydro-oxide formed during the hydration Tri-Calcium Silicate and Di-Calcium Silicate. Due to the reaction between micro Alumina particles and Calcium Hydro-oxide, more surface is available for further hydration process of Tri-Calcium Silicate and Di-Calcium Silicate. As a result, more Calcium Silicate Hydrate (C-S-H) gel form contributes to more strength.

The main reason behind the decrement in compressive strength from 3% to 7% of micro Alumina particles is that between these percentages, micro Alumina is available in excess quantity to react with total available quantity of Calcium Hydro-oxide to produce C-S-H gel due to which the surplus quantity of micro Alumina particles starts to agglomerate in concrete mixture and leads to form a weak zone. Consequently, compressive strength decreases.

The main reason behind the improvement in compressive strength from 8% to 12% of micro Alumina particles is that micro Alumina particles act as fine aggregate if present in a higher percentage. . Due to which small pores present in Concrete fill effectively with micro Alumina particles which are not possible with sand particles alone due to bigger particle size. Therefore Concrete becomes more dense and compact. Consequently, compressive strength increases.

The main reason behind the decrement in compressive strength from 13% to 15% of micro Alumina particles is that with increased micro Alumina particles, cement content reduces for a particular volume of Concrete. So that during the hydration process, less Calcium Silicate Hydrate (C-S-H) gel forms. As a result, compressive strength decreases.

4.3 Cost Analysis:

According to mix design for 1 m^3 of M25 concrete quantity of raw materials as follows:

Cement = 402.36kg = 8.047 Bags

Sand = 0.255m^3

Coarse Aggregate = 0.420m^3

Cost of materials:

Cement = 270 Rs. Per bag

Sand = 540Rs.per m^3

Coarse Aggregate = 1050 Rs. per m^3

Micro Alumina Particles = 25 Rs. Per kg

Cost of materials for 1 m^3 of M25 concrete:

Cement = 2172.69 Rs.

Sand = 137.7 Rs.

Coarse Aggregate = 441Rs.

Total Cost = 2751.39 Rs. (Controlled Concrete)

Cost of 1% of Micro Alumina Particles = 100.575Rs.

Every 1% increment in micro Alumina particles' total cost of 1 m^3 of concrete increases by 112.025 Rs.

V. CONCLUSIONS

From this experimental study, it can be concluded that for M-25 grade of Concrete, if a certain percentage of micro Alumina particles (by weight of cement) is added to cement, Concrete's compressive strength is compressive improves significantly. 12% dosage of micro Alumina particles increases the 28 days compressive strength by 22.79%(peak value) compared to controlled Concrete and decreases the 7 days compressive strength by 25.45%as compare to controlled Concrete. However, the 2% dosage of micro Alumina particles increases the 28 days compressive strength by 14.79% compared to controlled Concrete and increases the 7 days compressive strength by 10.75%as compare to controlled Concrete. In both cases (2% and 12%

dosage of micro Alumina particles), the strength gain rate for 28 days is higher than the strength gain rate for 7 days. 12% dosage of micro Alumina particles increases the total cost of M-25 Concrete (per cubic meter) by 1207.075Rs. and2% dosage of micro Alumina particles increases the total cost of M-25 Concrete by 201.175Rs. This indicates that the addition of 2% of micro Alumina particles is more economical. So that it is concluded that the recommended dosage of micro Alumina particles are 2% (by weight of cement).

CONFLICT OF INTEREST

"This submitted work is not related to any conflict of interest."

AUTHOR CONTRIBUTIONS

Mr. Pukhraj Sahu has given his valuable guidance from starting to the ending point, and with the help of his guidance, Vishnu Chakravarty has conducted the research work and wrote the paper.

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