Effect of Combined Percentage Volume of Micro Silica and Nano Silica on Mechanical Properties of Concrete

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Abstract- *The present investigations give us a detailed concept regarding the behavior of concrete under the action of highly reactive mineral admixtures with different combinations. Many scientists and researchers developed a few procedures to amend the parameters of the concrete like strength and durability. The present paper worked out on the new technology say Nanotechnology, which consists of non-crystalline product i.e. micro silica (MS) and nano silica (NS). The theme of the paper presents a promising area of science with various strength characteristics of concrete containing micro-silica and nano-silica. The combined appliances of both MS & NS on various assests of M40 grade concrete are studied. Cement is partially replaced by combination of 5% and 10% of MS and 1.5% & 3% of NS by weight. The tests conducted on controlled concrete and replaced concrete are compression strength, split tensile strength for 7, 28 and 56 days of curing. The test results of M40 grade concrete is prepared by using different magnitudes of micro and nano silica are compared with plain concrete, Based on the test results. Concrete prepared with a combination of 10% MS & 1.5% of NS posses an improvement in strength characteristics that attributes to effective particle packing and additional availability of binder during hydration in the presence of Nano materials.*

I. INTRODUCTION

A very massive change has been at the end of the 20 th century. When it compared from the beginning of the century. The unique technological changes for the innovations in communication, medicine, transportation, science and engineering from the half of the last century. The construction industry has been no exclusion for these changes, the stimulating achievements in the design and construction of bridges, offshore structures, dams and buildings.

1.1 ROLE OF CEMENT INDUSTRY IN GLOBAL WARMING:

Ordinary Portland cement (OPC) comprises of 95% residue and 5% gypsum. The residue is produced from crushing limestone together with other minerals and then heating the materials for high temperatures (900-14500C). During finishing the gypsum is added to the residue as it is ground to a small particle size (typically 10-15 microns). The residue is large amount energy and emissions concentrated aspect of cement production. Therefore it is known as“The Residue factor “. By reducing the residue factor the global warming potential of the cement is also reduced. It can be achieved in blended cements. we can find these blended cements in popular places like Europe than in North America , UK and most of Asia.

For every ton of residue produce 0.9 tons of CO2 emitted. Only between 0.3 and 0.4 tons of CO2 energy used is responsible for reduction of the emissions. We cannot reduce the 0.53 tons of CO2 emitted for every ton of residue. The CO2 released from the calcinations of limestone is known as the “process emissions”. This when heated breaks down into CO2 and quicklime.

In the last 25 years there have been 30% reductions in CO2 emissions as per the report published on 2006 by some reputed companies. This kind of independent evaluation is intended for adoption of more fuel efficient kiln processes.

By increasing the utilization of alternative renewable fuels and by the production of blended cements with mineral additions substituting residue there can be a potential improvement. For every ton of cement Europe’s low residue factor translates to a lower energy which is 74% of the global average. For every ton of CO2 emitted Europe emits only 64% of the global average. So it is our responsibility to reduce the cement usage by replacing with mineral admixtures.

II. PROJECT OBJECTIVE

The main objective of the present investigation is: To obtain the influence of the combined application of Micro silica and Nano silica on various strength properties of M 40 grade concrete.

Compressive strength, split ensile strength of M40 grade concrete prepared using different combine proportions of Nano silica and Micro silica are to be obtained and the results are to be compared with that of controlled concrete.

III. PROPERTIES OF MICRO SILICA AND NANO SILICA

3.1 MICRO SILICA:

Micro silica also called as silica fume is an unstructured that is non crystalline polymorph silica. This is the byproduct of silicon and Ferro silicon alloy production that is collected as powder and this consists of particles which are spherical and its diameter is about 150 nm.

The silica fume is a solid ultrafine substance or material which consists of particles that are spherical of diameter 1 µm where the average content is about 0.15µm. this is about one hundred times smaller compared to an average cement particle. The range of silica fume specific gravity is around 2.2 to 2.3. We can measure the silica fume specific surface area by using a method called BET or any such similar method called nitrogen absorption. Since the silica has a greater quality and caliber it is very actual in its material. The normal specifications used in the silica fume mixtures are cement contained and those are EN13263, ASTMC1240.

Figure.1. Nano silica

3.2 NANO SILICA

These days a lot of various approaches and procedures are there for producing nano silica. The first type of technique is a process of sol gel within the temperature of room. During this procedure the materials like Na2SiO4 and metallic organs are mixed with the solvent and later the pH value of the solution is altered with respect to the silica gel precipitation. This gel which is produced is kept for long and later filtered to develop into a zero gel. This type of gel is first dried and later it is mixed or distributed with the steady solution of NaK NH3.

The substitute method for this production is nothing but vaporizing the silica in between 1500 and 2000c by reducing the material Quartz through the electric based furnace. By compressing the successive particles in the cyclone mode the nano silicon is obtained as silicon metals and Ferro silicon alloy which is a byproduct of this nano silicon. This kind of silicon produced is a material which consists of particles that are spherical of diameter whose specific surface area is high that is up to 25m2/g.

The silicon ferry and nano silicon are higher in price for general usage purpose therefore these are used in concretes of eco and concretes of self compacting. Regarding these two types of concretes that is concrete of eco and concrete of self compacting the special concrete application is necessary. And some high performing nano silica applications are required for slurries of cement and for mortars which are specialized for filling the rock-matching. In the current process the particleboard of gypsum is not used. This kind of concrete is used in major purposes like buildings, construction and infrastructure. NS is applied mainly in high performance concrete and self compacting concretes mainly as an agent of anti bleeding. It is also useful for increasing the cohesiveness and strength of the mixtures. According to the major publications technically it is referred that nano silica is excessively used as an additive. The replacement of waste materials by completely burnt sludge ash and ordinary sludge ash is known as eco concretes. There is serious concern in these mixtures that is low compressive strength but as in the case of NS there is no problem of giving less strength.

Figure.2. Micro silica

IV.REVIEW OF LITERATURE

Rui zhong & kay wille, (2015) Dealt with the SF and immoderate fine silicon oxide powder to enhance the ultra high performance pervious concrete matrix. to attain the goal of an immoderate high performance cement with compressive strength in way over 150 Mpa.

V.T. Giner et al. (2011) Studied the influence of SF addition within the quantities starting from 0-15% of cement mass on the dynamic and static mechanical properties of concrete.

Shitole et al. (2014); It can be concluded that 7.5% replacement of cement by micro silica can cause higher strength properties to normal concrete. Thus micro silica can be used to achieve the higher strength & it also helps to reduce air pollution.

Ji et al. (2015) studied the water permeability resistant behavior and microstructure of concrete with Nano silica and observed that the Nano silica concrete has a better water resistant permeability than the ordinary concrete which is manufactured using ordinary Portland cement.

DESIGNATION M40	CEMENT Kg/m3	MICRO SILICA Kg/m3	NANO SILICA Kg/m3	WATER Kg/m3	FINE AGGREGATE Kg/m3	COARSEAGGREGATE Kg/m3 1180	
						10mm	20mm
$C_{100}M_0N_0$	400	0	0	160	650	472	708
$C_{93.5}M_5N_{1.5}$	374	20	6	160	650	472	708
$C_{88.5}M_{10}N_{1.5}$	354	40	6	160	650	472	708
$C_{92}M_5N_3$	368	20	12	160	650	472	708
$C_{87}M_{10}N_3$	348	40	12	160	650	472	708

NOTE: Poly carboxylate is used as a super plasticizer

V. EXPERIMENTAL WORK

5.1 MATERIALS AND THEIR PROPERTIES

The properties of various materials used in making the concrete are discussed in the following sections.

Cement:

The Ordinary Portland Cement of 53 grade is used specifying all the properties from IS12269-1987.

Coarse Aggregate:

20mm and 10mm coarse aggregate are selected by passing the aggregate through 20mm and 10mm sieves respectively. Particle shape of both the aggregate is angular. Different test are to be conducted like specific gravity, fineness modulus and water absorption. Coarse aggregate is dust free and free from surface moisture.

Fine Aggregate:

Natural Sand is selected as fine aggregate. Sand is sieved from 4.75 mm sieve and also washed to reduce the silt content. Here, water demand is slightly less for natural sand, which is therefore more preferable. The specific gravity, fineness modulus and water absorption test are conducted on Natural sand.

Figure.3.Slump test

VI. LABORATORY TESTS AND RESULTS

Various tests were carried out in the laboratory for finding the strength and durability and other important properties of the concrete used during the study. Slump cone test, Compaction test, compressive strength and split tensile strength were conducted and the details of these tests are given in the following sections.

6.1 EXPERIMENTAL PROCEDURE

SLUMP CONE TEST: In all over the world the test on fresh concrete are widely used .though the slump test won't consider the workability of concrete but helpful in detecting the deviations in the uniformity of a mix of given nominal proportions.

6.2 WORKABILITY OF FRESH CONCRETE

Workability depends on water content, aggregate (shape and size distribution), cementicious content and age (level of hydration) and can be modified by adding chemical

%NS and %MS REPLACEMENT	SLUMP VALUE(MM)	TYPES OF SLUMP
$C_{100}M_0N_0$	95	TRUE
$C_{93.5}M_5N_{1.5}$	72	TRUE
$C_{88.5}M_{10}N_{1.5}$	65	TRUE
$C_{92}M_5N_3$	76	TRUE
$C_{87}M_{10}N_3$	60	TRUE

admixtures, like super plasticizer. Raising the water content or adding chemical admixtures increases concrete workability.

TABLE COMPRESSIVE STRENGTH RESULT FOR 7, 28, 56 DAYS

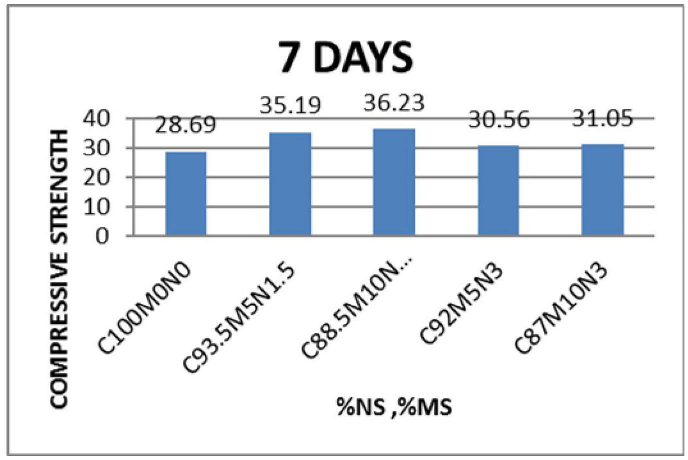
S.NO	Mix	COMPRESSIVE STRENGTH (N/MM2)			AVERAGE SPLIT TENSILE STRENGTH (N/MM2)		
		7 DAYS	28 DAYS	56DAYS	7 DAYS	28 DAYS	56 DAYS
1	$C_{100}M_0N_0$	30.10	50.25	56.65			
		26.52	44.81	51.70			
		29.44	45.66	53.98	28.69	47.80	52.26
2	$C_{93.5}M_5N_{1.5}$	34.26	57.01	63.89			
		37.21	57.90	58.56			
		34.09	57.03	61.45	35.19	57.32	60.26
3	$C_{88.5}M_{10}N_{1.5}$	38.32	60.72	65.23			
		33.09	62.61	60.23			
		37.21	55.19	63.78	36.23	59.51	62.54
4	$C_{92}M_5N_3$	29.76	54.94	56.15			
		32.62	48.83	54.63			
		29.30	47.18	51.96	30.56	50.32	53.79
5	$C_{87}M_{10}N_3$	31.28	48.51	59.86			
		33.33	54.09	54.62			
		31.34	51.69	55.06	31.05	51.41	55.23

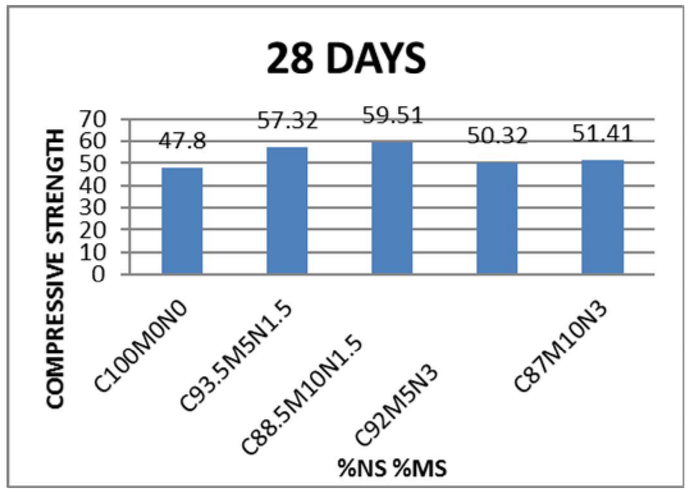
VII. COMPRESSIVE STRENGTH

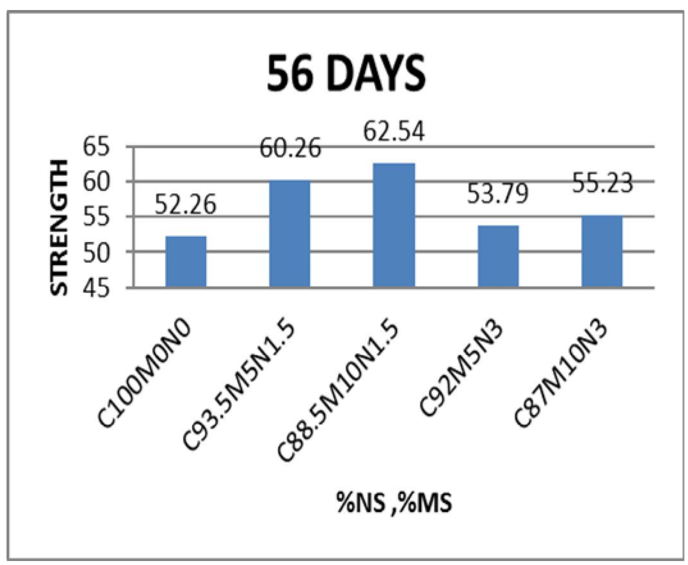
Compression test is the most pervasive test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the sought-after trait properties of concrete are qualitatively related to its compressive strength. The cube specimen is of the size 15 x 15 x 15 cm. The largest nominal size of the aggregate does not exceed 20mm, 10cm size cubes may also be used as an alternative

Figure.4.Testing of compressive strength of specimen

7.1 Graphical representation of Compressive Strength Values







For 7 days compressive strength test:

For $C_{93.5}M_5N_{1.5}$, there is an increase in strength of 22%. when compared with $C_{100}M_0N_0$.

For $C_{88.5}M_{10}N_{1.5,}$ there is an increase in strength of 26.2%. when compared with $C_{100}M_0N_0$.

For $C_{92}M_5N_{3,}$ there is an increase in strength of 6.5%. when compared with $C_{100}M_0N_0$.

For $C_{87}M_{10}N_{3,}$ there is an increase in strength of 8.22%. when compared with $C_{100}M_0N_0$

For 28 days compressive strength test:

For $C_{93.5}M_5N_{1.5}$, there is an increase in strength of 19.9%. when compared with $C_{100}M_0N_0$.

For $C_{88.5}M_{10}N_{1.5,}$ there is an increase in strength of 24.10%. when compared with $C_{100}M_0N_0$.

For $C_{92}M_5N_{3,}$ there is an increase in strength of 5.27%. when compared with $C_{100}M_0N_0$.

For $C_{87}M_{10}N_{3,}$ there is an increase in strength of 7.55%. when compared with $C_{100}M_0N_0$

For 56 days compressive strength test

For $C_{93.5}M_5N_{1.5}$, there is an increase in strength of 15.3%. when compared with $C_{100}M_0N_0$.

For $C_{88.5}M_{10}N_{1.5,}$ there is an increase in strength of 19.67%. when compared with $C_{100}M_0N_0$.

For $C_{92}M_5N_{3,}$ there is an increase in strength of 2.92%. when compared with $C_{100}M_0N_0$.

For $C_{87}M_{10}N_{3,}$ there is an increase in strength of 5.68%. when compared with $C_{100}M_0N_0$

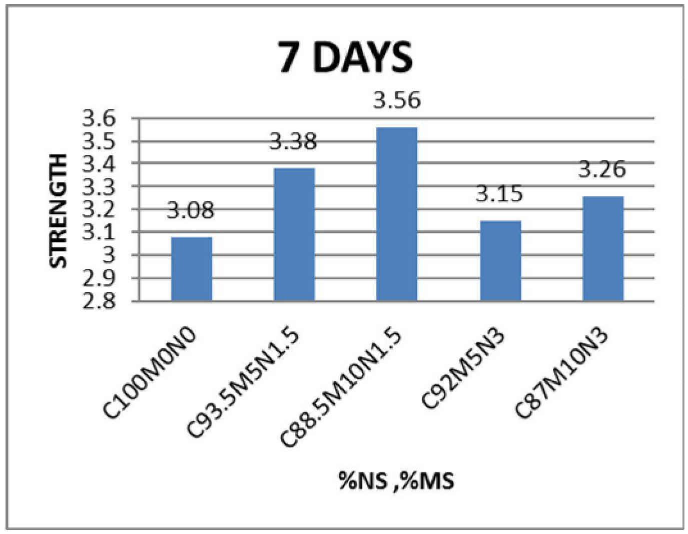
VIII. SPLIT TENSILE STRENGTH

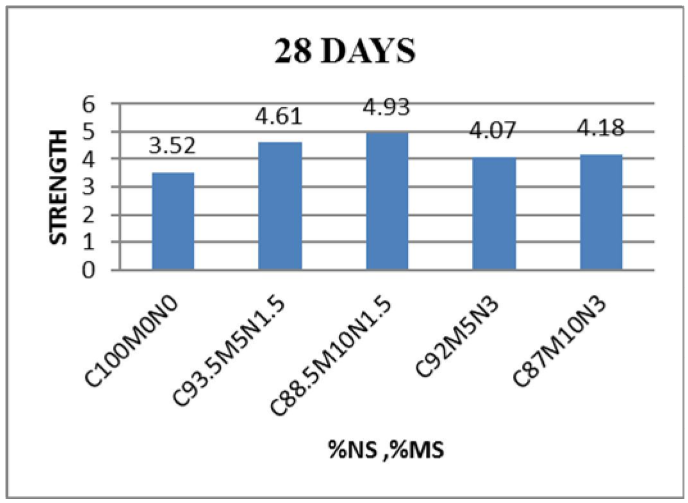
The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. Cracking is a form of tension failure. From the below formula the split tensile strength of the specimen is determined, the load at which the concrete members may crack. Cracking is a form of tension failure. The usefulness of the split tensile test for assessing the tensile strength of concrete in the laboratory is widely accepted and the usefulness of the above test for control purposes in the field is under investigation.

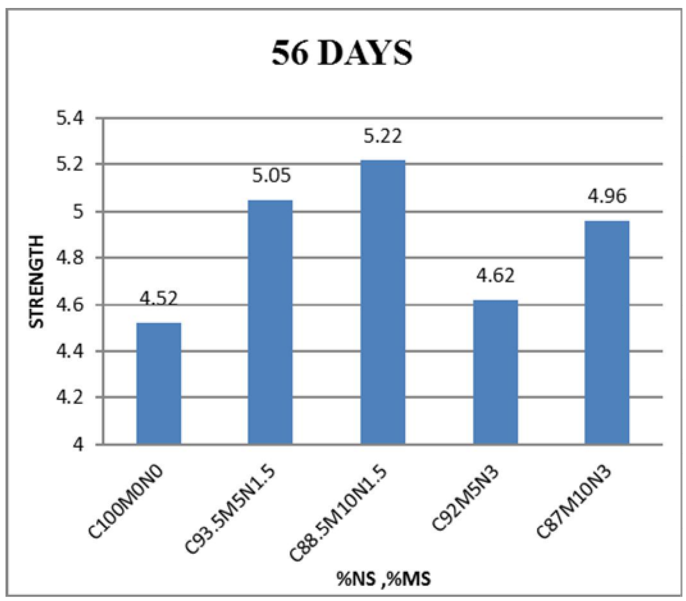
Split tensile strength= 2P/ (ΠDL)

P = ultimate load, L= span of the specimen, D= width of the specimen.

8.1 Graphical representation of Split Tensile Strength Values:







For 7 days split tensile strength test:

For $C_{93.5}M_5N_{1.5}$, there is an increase in strength of 9.74%. when compared with $C_{100}M_0N_0$.

For $C_{88.5}M_{10}N_{1.5,}$ there is an increase in strength of 15.58%. When compared with $C_{100}M_0N_0$.

For $C_{92}M_5N_{3,}$ there is an increase in strength of 2.27%. when compared with $C_{100}M_0N_0$.

For $C_{87}M_{10}N_{3,}$ there is an increase in strength of 5.84%. When compared with $C_{100}M_0N_0$.

For 28 DAYS split tensile strength;

For $C_{93.5}M_5N_{1.5}$, there is an increase in strength of 30.96%. When compared with $C_{100}M_0N_0$.

For $C_{88.5}M_{10}N_{1.5,}$ there is an increase in strength of 40.5%. when compared with $C_{100}M_0N_0$.

For $C_{92}M_5N_{3,}$ there is an increase in strength of 15.62%. When compared with $C_{100}M_0N_0$.

For $C_{87}M_{10}N_{3,}$ there is an increase in strength of 18.75%. when compared with $C_{100}M_0N_0$

For 56 DAYS split tensile strength:

For $C_{93.5}M_5N_{1.5}$, there is an increase in strength of 11.6%. when compared with $C_{100}M_0N_0$.
For $C_{88.5}M_{10}N_{1.5,}$ there is an increase in strength of 3.98%. when compared with $C_{100}M_0N_0$.
For $C_{92}M_5N_{3,}$ there is an increase in strength of 2.2%. When compared with $C_{100}M_0N_0$.

For $C_{87}M_{10}N_{3,}$ there is an increase in strength of 9.7%. when compared with $C_{100}M_0N_0$.

Figure.5.Testing of split tensile strength of specimen

TABLE SPLIT TENSILE STRENGTH RESULT FOR 7, 28, 56 DAYS

S.NO	Mix	SPLIT TENSILE STRENGTH (N/MM2)			AVERAGE SPLIT TENSILE STRENGTH (N/MM2)		
		7DAYS	28DAYS	56DAYS	7DAYS	28DAYS	56DAYS
1	$C_{100}M_0N_0$	3.09	3.99	3.85	3.08	3.52	4.52
		3.22	4.12	4.98			
		2.93	3.83	4.73			
2	$C_{93.5}M_5N_{1.5}$	4.25	4.73	5.64	3.38	4.61	5.02
		3.35	4.92	4.80			
		2.55	4.18	4.71			
3	$C_{88.5}M_{10}N_{1.5}$	4.50	4.85	4.88	3.56	4.93	5.22
		3.40	5.04	5.86			
		2.80	4.90	4.92			
4	$C_{92}M_5N_3$	4.12	3.86	4.92	3.15	4.07	4.62
		3.16	4.13	4.96			
		2.16	4.22	3.98			
5	$C_{87}M_{10}N_3$	3.25	4.17	5.70	3.26	4.18	4.96
		3.40	4.32	4.63			
		3.13	4.05	4.55			

C100M0N0 – cement 100%, micro silica -0%, nanosilca -0%
C93.5M5N1.5 – cement 93.5%, micro silica -5%, nanosilca -1.5%
C88.5M10N1.5 – cement 88.5%, micro silica -10%, nanosilca -1.5%
C92M5N3 – cement 92%, micro silica -5%, nanosilca -3%
C87M10N3 – cement 87%, micro silica -10%, nanosilca -3%

IX. CONCLUSIONS

- The slump decreases as the percentage of micro silica and nano silica increases. This is due to the specific surface area of micro silica and nano silica is much higher than cement and corresponding the water demand raises so that the slump decreases.
- It is also observed that while increasing the combine percentage of MS and NS the concrete become more cohesive and there is no problem of bleeding and segregation.
- The compressive strength and split tensile strength is maximum for $C_{88.5}M_{10}N_{1.5}$
- The compressive strength and split tensile strength is high at $C_{88.5}M_{10}N_{1.5}$ at all ages i.e. that are 7 days, 28 days and 56days.
- As the percentage replacement by micro silica and nano silica increases beyond the strength decreases. From this investigation the optimum proportion of mix is $C_{88.5}M_{10}N_{1.5.}$

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