International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 01 | Jan -2017 www.irjet.net p-ISSN: 2395-0072

STRENGTH AND DURABILITY PROPERTIES OF SELF-COMPACTING CONCRETE WITH MICRO SILICA AND NANO SILICA

E. Siva Subramanian[1], P. Arunkumar[2], N. Arul[3]

[123] *Asst Professor, Department of Civil Engineering, V.S.B Engineering College, Karur, India*

Abstract - This experimental study demonstrates that Nano Silica (NS) & Micro Silica(MS) can be successfully used as an admixture in the preparation of self-compacting concrete (SCC). In order to prepare suitable mix proportions of micro silica and nano silica specimen indicated that, a more suitable and strength gaining in SCC is combination of micro silica and nano silica, that is concrete with combination of 15% of micro silica and 3 liters of nano silica improve the compressive strength, split tensile strength, flexural strength by 25.61%, 25%, 19% respectively. The compressive strength, split tensile strength and flexural strength of the specimens have been analyzed for 7-days and 28 days curing. From the study it is observed that mechanical properties such as Compressive strength, Split tensile strength and Flexural strength test increase in mixing of micro silica and nano silica. The fresh concrete test results revealed that by substituting different percentages of MS and NS in SCC, satisfactory workability and rheological properties can be achieved, by using viscosity modifying agent. The engineering properties of SCC such as Saturated Water absorption, Sulphate Resistance, Acid Resistance improved while designing 15% of micro silica with 3 % of nano silica.

Keywords: Self Compacting concrete, Nano silica, Micro silica, Saturated Water absorption, Sulphate Resistance

1. INTRODUCTION

These days, apart from steel, concrete is the most common and widely used as structural material in construction field. Concrete defined as a composite material made up of composed granular material (the aggregate or filler) embedded in a hard matrix of material (cement or binder) and water. They are many types of concrete with different material used in mix design. The Self Compacting Concrete is a concrete which flows and settles due to its own weight without segregation and bleeding. SCC has several advantages over normal conventional concrete. It can flow easily in congested reinforced areas such as in beam column joints.

The terms "High performance concrete" and "High strength concrete" are often taken to mean the same thing. However, as indicated, "High performance" strictly relates to a concrete that has been designed to have good specific characteristics, such as high resistance to chloride ingress or high abrasion resistance, as a result it may also have a high strength. High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lower the overall cost of the structure. The most common use of high strength concrete is for construction of high-rise buildings.

1.1 Self Compacting Concrete

Development of Self-Compacting Concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-situ concrete. SCC is not affected by skills of labours, the shape and amount of reinforcement or the arrangement of a structure and due to its high fluidity and resistance to segregation it can be pumped longer distances. The concept of SCC was proposed in 1986 by Professor Hajime Okaruma, but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo. SCC was developed at the time to improve the durability of concrete structures. Since then, various investigations have been carried out and SCC has been used in practical structures in Japan, mainly by large construction companies. Investigations for establishing a rational-mix design method and Self-Compacting testing methods have been carried out from the viewpoint of making it a standard concrete.

Mineral admixtures are uses as an extra fine material, besides cement, and in some cases, they partially replace cement. In this study, the cement content was partially replaced with mineral admixtures, micro silica and nano silica that improve the flowing and strengthening characteristics of the concrete.

The main reasons for the employment of SCC can be summarized as follows:

- To shorten the construction period.
- To assure compaction in the structure- especially in confined zones where compaction is difficult.
- To eliminate noise due to vibration.

2. MATERIALS PROPERTY

The concrete mixtures investigated in this study were prepared with Portland cement type II, micro silica powder and nano silica. The specific gravity of micro silica and nano silica is 2.17 and 1.03, and they are silica particles with a maximum size of 0.2 µm and 50 nm, respectively. In addition, nano silica is a water emulsion with 50 % of dry solid and PH of 10.. The control mix which was exclude of micro silica and nano silica.

Figure 1.1 Micro Silica

Figure 1.2 Nano Silica

Table - 1: Properties of Micro silica

Chemical composition	%
SiO_2	85-95
C	0.6 -1.5
Fe_2O_3	0.4-2
Cao	2-2.3
Al_2O_3	0.5 – 1.7
MgO	0.1 – 0.9

Table - 2: Properties of Nano silica

Solid content (SiO_2-content)	50 wt %
Density	1.4 g/cm^3
ph	9.5
Viscosity	<15cPS

3. EXPERIMENTAL INVESTIGATION

A partial replacement of cement micro silica and nano silica concrete was mixed in various percentages as 10, 15% respectively cubes, cylinder and prism.

The cube compressive strength, cylinder split tensile strength, prism flexural strength for the various mixes was also done. After evaluating the mechanical properties for the various mix and it is compared with its performance of lime stone power in the self compacting concrete and for the best result, the durability test is conducted and tested The details of the experimental investigation regarding the materials, methods of mixing, casting and testing of specimens are presented in this chapter.

Table - 3: Self Compacting Concrete with Combination of Micro Silica & Nano Silica

% of Micro silica	Nano silica (%)	Compressive strength at 28 days (mpa)	Split tensile strength at 28 days (mpa)	Flexural strength at 28 days (mpa)
0% MS	0	52	3.95	5.0
	2	52.55	3.98	5.0
	3	52.90	4.15	5.15
	4	53.10	4.10	5.20
5% MS	0	53.75	4.10	5.25
	2	57.50	4.25	5.75
	3	63.00	4.80	5.80
	4	68.00	4.95	5.90
10% MS	0	56.85	4.70	5.68
	2	61.90	4.95	5.80
	3	64.00	5.10	5.90
	4	66.00	5.20	5.96
15% MS	0	60.50	4.96	5.95
	2	68.00	5.15	5.98
	3	76.00	5.20	6.10
	4	69.00	5.25	6.25
20% MS	0	55.75	4.92	5.60
	2	65.00	4.95	5.70
	3	67.00	4.98	5.75
	4	66.50	5.00	5.80

Table - 4: Saturated Water Absorption Test

Mix ID	Initial weight (Weight after 28 days)	Final weight (Weight after 72° oven dry)	% of Weight loss
SCC	8.344	8.138	2.5
	8.862	8.642	2.5
	8.756	8.592	1.9
SCC+ 15 % Micro silica with 3% of nano silica	8.454	8.310	1.7
	8.348	8.208	1.7
	8.353	8.199	1.8

Table - 5: Sulphate Resistance Test

Mix ID	Initial weight (Weight after 28 days)	Final weight (After 30 days immersion in $MgSo_4$)	% of Weight loss
SCC	8.678	8.665	0.10
	8.646	8.642	0.04
	8.652	8.647	0.05
SCC+ 15 % Micro silica with 3% of nano silica	8.435	8.428	0.08
	8.457	8.454	0.03
	8.402	8.398	0.04

Table - 6: Acid Resistance Test

Mix ID	Initial weight (Weight after 28 days)	Final weight (After 30 days immersion in HCL)	% of Weight loss
SCC	8.474	8.278	2.3
	8.138	8.023	1.4
	8.458	8.364	1.1
SCC+ 15 % Micro silica with 3 % of nano silica	8.480	8.325	1.8
	8.391	8.296	1.1
	8.248	8.174	0.9

4. CONCLUSIONS

Based on experimental research for three self compacting concrete mixes (only micro silica, nano silica and combination of micro and nano silica), the following conclusions can be drawn at 28 days.

1. Due to observed workability and high flow ability of SCC, it can be used in highly congested reinforcement structure as compare to conventional concrete.

2. Using nano silica in SCC individually there is no greater differences in strength gaining as compared to conventional concrete, but it as improve the flexural strength upto 5% using 3% of micro silica.

3. The concrete with addition of 15% micro silica(based on the mass of cement) in SCC, the compressive strength, split tensile strength, flexural strength increased by 22%, 25%, 19% respectively.

4. As a general conclusion, the comparison results of micro silica, nano silica, combination of micro silica and nano silica specimen indicated that, a more suitable and strength gaining in SCC is combination of micro silica and nano silica, that is concrete with combination of 15% of micro silica and 3 litres of nano silica improve the compressive strength, split tensile strength, flexural strength by 25.61%, 25%, 19% respectively.

5. The engineering properties of SCC such as Saturated Water absorption, Sulphate Resistance, Acid Resistance improved while designing 15% of micro silica with 3 % of nano silica.

REFERENCES

[1] Amar Devendra Shitole, & Sandhya Mathpati, "The Use of Micro-Silica To Improve The Compressive and Flexural Strength of Concrete", International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, 2(8), Aug 2014.

[2] Alsana Bashir, Misba Gul, Javed A Naqash, Ajaz Masood, "Study of Permeability and Compressive Strength of Silica Fume Concrete", International Journal of Engineering and Advanced Technology, ISSN: 2249 – 8958, 3(4), April 2014.

[3] Ha-Won Song, Seung-Woo Pack, Sang-Hyeok Nam, Jong-Chul Jang and Velu Saraswathy, "Estimation of the Permeability of Silica Fume Cement Concrete", Construction and building material, 24, 315–321, 2010.

[4] Hou, P., Kawashima, S., Kong, D., Corr, D. J., Qian, J., & Shah, S. P, "Modification Effects of Colloidal Nano SiO^2 on Cement Hydration and its Gel Property", Composites Part B: Engineering, 45, 440– 448, 2013.

[5] Ltifi, M., Guefrech, A., Mounanga, P., & Khelidj, A, "Experimental Study of the Effect of Addition of Nano-silica on the Behaviour of Cement Engineering", 10, 900–905. Mortars Mounir. Procedia, 2011.

[6] Li, H., Xiao, H. G., & Ou, J, "A Study on Mechanical and Pressure-sensitive Properties of Cement Mortar with Nanophase Materials", Cement and Concrete Research, 34, 435–438, 2005.

[7] Mastafa Jalal, Esmaeel Mansouri, Mohammad Aharifipour, Ali and Reza Pouladkhan, "Mechanical, Rheological, Durability and Micro Structural Properties of High Performance Self Compacting Concrete Containing SiO^2 Micro and Nanoparticles", Materials and Design, 34, 389–400, 2012.

[8] Min-Hong Zhang, Jahidul Islam and Sulapha Peethemparan, "Use of Nano Silica to Increase Early Strength and Reduce Setting time of Concretes with High Volumes of Slag", Cem. and Con. Compo, 34, 650–662, 2012.

[9] Mohammad Reza Zamani Abyaneh, Alireza Mehran, Seyed Mohammad Mahdi Hoseini, "Effects of Nano-Silica on Permeability of Concrete and Steel Bars Reinforcement Corrosion", Australian Journal of Basic and Applied Sciences, 7(2): 464–467, 2013 ISSN 1991-8178, 2013.

BIOGRAPHIES

E. Siva Subramanian
Assistant Professor
Department of Civil Engineering
V.S.B Engineering College, Karur

P. Arunkumar
Assistant Professor
Department of Civil Engineering
V.S.B Engineering College, Karur

N. Arul
Assistant Professor
Department of Civil Engineering
V.S.B Engineering College, Karur