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EXPERIMENTAL INVESTIGATION ON NANOSILICA AND THE BEHAVIOUR OF ORDINARY PORTLAND CEMENT AND BLENDED CEMENT AND ITS EFFECTS ON PROPERTIES

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ABSTRACT: Concrete is the most common material for construction. The total production depends upon the cement content only. Due to the usage, large amount of cement produces increasing the CO_2emissions, to reduce the cement percentage in concrete mixes the nanosilica ($nSiO_2$) is used as the replacement of the cement. Nowadays is mainly focusing on the basic science of cementitious material at atomic or nano level. Further, researches are continuing to improve the sustainability and durability of concrete and it has the mechanical properties and significant increment in cementitious material. This paper summarizes the effect of nano silica addition on mechanical properties of concrete. It provides the current development of application of nano-silica in motor and concrete by using Ordinary Portland Cement and Blended Cement. The nano silica is available in 10-50 nm as particle size. The 17nm particle size is used for the whole project. This paper aim is to study the mechanical properties of the specimen using the nano silica by replacement of the cement. The ratio in weight of the nano cement with respect to normal cement. The mortar specimen size is 70.6x70.6x70.6 mm. The concrete cube size is 150 x 150 x 150 mm was maintained and water cement ratio 0.40 was maintained throughout the project. The 0%, 1.5%, 3.5%, 5.5% and 7.5% of nano silica should be replaced with weight of the cement.

Key words: Nano silica, Compressive strength, Split tensile strength,X-Ray Diffraction, SEM analysis, Cement type: OPC and Blended Cement.

1. INTRODUCTION

Concrete's versatility durability and economy have made it the world's most used construction material. The India utilizes about 7.3 million cubic meter of concrete each year. Due to this the cost of construction increases and causes environment pollution. As the demand for concrete as a construction material increase, so also the demand for fine aggregate increase.

In recent years, Global warming and environmental destruction have become major problems. Heightening concern about worldwide ecological issues, changeover the large scale manufacturing, mass-utilization, mass-waste, society of the past to a zero-emission society is presently seen as essential.For reducing the pollution we used the nano-silica as the percentage replacement of the cement.

One of the most used nano-sized material is nano-silica. Nano-silica addition increases the compressive strength and it reduces the permeability of hardened concrete. The interesting properties of and the incorporation of nano–silica deteriorate consistency of cement composites.

The presence of nano silica contributed to the improvement of the compressive strength and split tensile strength.The performance of cement based material is strongly dependent on nano sized particles. The particles of calcium-silicate-hydrates (C-S-H) at the interfacial

transition zone between the cement and aggregate.The nanosilica decreases the setting time when comparing with the silica fume.

In view of this advance the main aim of this experiment is to study the mechanical properties of the structure. In this study the influence of size 17 nm and quantity 0, 1.5, 3.5, 5.5 and 7.5% by weight of cement of $nSiO_2$on the mechanical properties have been examined.

.The nano silica will be mixed with mortar, cement paste and concrete. The addition of nano silica mixture gives the mechanical properties, durability properties. In this project the nano silica will be mixed with mortar and concrete and it gives the high mechanical property when comparing to the conventional mortar and concrete.

2. MATERIALS

2.1 Ordinary Portland Cement

Ordinary Portland cement of manufactured by Zuari Company, conforming to IS 12269: 1989,53 grade cementwas used. The specific gravity of the cement is 3.15. The initial and final setting times were found as 30 minutes and 600 minutes respectively.

Table 1: Physical properties of cement

PARTICULARS	RESULTS
Specific gravity	3.15
Initial setting time	30 mins
Final setting time	600 mins

Table 2: Chemical composition of cement

Oxide	Percent content
CaO	60-67
SiO_2	17-25
Al_2O_3	3.0-8.0
Fe_2O_3	0.5-6.0
Mgo	0.1-4.0
Alkalies (K_2O,Na_2O)	0.4-1.3
SO_3	1.3-3.0

2.2 Blended Cement

The Evidence of the first Blended Cements dates came to Roman times, when volcanic ash was used in blend with slaked lime to give the user a product and it is developed higher early strength than the usual slaked lime. Evidence of this can be seen in the Aqueducts and the Colosseum in Rome. In Italy where the volcanic ash was discovered that area is called Pozzuola, hence the term being called a pozzolan. In truth, it is more likely that the lime the Romans calcined (burnt) for the purpose of slaking approached an argillaceous lime in chemical composition and rather than it has milled to be naturally slaked position.

A mixture of Portland Cement and other material like as pozzolana, hydrated lime, etc., combined either during or after the finish grinding of the cement at the mill. Concrete can be produced with blended cement containing cementitious materials most commonly silica or fly ash should added at the batch plant.

2.3 Fly ash based Blended Cement

Initial experiments like compressive strength test on mortar cubes and concrete cubes were conducted on Ordinary Portland Cement and Portland Pozzolana Cement(being referred as Blended Cement in the present study).

The physical and chemical composition of Blended Cement was supplied by the manufacturing company.

Table 3 :Chemical composition

SI.No	Parameter	Result
1.	Insoluble Material (% by mass)	18.90
2.	Magnesia (% by mass)	0.99
3.	Sulphuric Anhydride (% by mass)	2.67
4.	Loss on Ignition (% by mass)	2.04
5.	Total Chlorides (% by mass)	0.001

Fig 1 Collection of cement

2.4 Fine Aggregate:

Normal sand : The normal sand collected from the Bahudha river and it is the locally available crushed sand, and it is passing through 4.75 mm IS. Sieve is used. The specific gravity of the sand is found to be 2.82.

Ennore sand: The Ennore sand is passing 50 microns IS Sieve. The specific gravity of Ennore sand is 2.64 and the Ennore sand is used for casting the mortar cubes by using Ordinary Portland Cement and Blended Cement.

Fig 2: Collection of fine aggregate

Natural Coarse-Aggregate:

It is collected from the R.K.Padu, it is locally available material. To obtain a reasonably good grading, 60% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. The specific gravity of the combined aggregate is 2.70.

Fig 3: Collection of coarse aggregate

Nanosilica:

The nano silica is purchased from Astraa chemicals at Chennai. The used nano silica having the pH value is 4.12. The particle size of thenano silica is 17 Nanometers. Chemical composition of silica fume is presented in Table 5.2. In the present experimental investigation, 1.5%, 3.5%,5.5%, and 7.5% of nano silica has been replaced with the cement.

2.5 Specifications of nano silica

Table 4: Specifications of nano silica

Test item	Standard requirements	Test results
Specific surface area (M^2/G)	200±20	202
pH Value	3.7-4.5	4.12
Loss in drying @105^{0}C (5)	≤1.5	0.47
Loss in ignition @ 1000^{0}C (%)	≤2.0	0.66
Sieve residue (5)	≤0.04	0.02
Tampered density g/l	40-60	44
SiO_2 content (%)	≥99.8	99.88
Carbon content (%)	≤0.15	0.06
Chloride content (%)	≤0.0202	0.009
Al_2O_3	≤0.03	0.005
TiO_2	≤0.02	0.004
Fe_2O_3	≤0.003	0.001
Specific gravity	2.2-2.4(generalised)	
Particle size	17 nano meters	

Fig 4: Collection of nano silica

2.6 Water:

Water has been used for mixing and as well as for curing the mortar and concrete specimens in the present experiment.

3. RESULTS AND DISCUSSION

The strength properties and results of the compressive strength for mortar cubes and concrete cubes, split tensile strength by without replacement of cement and with replacement of cement by nano Silica.

3.1 Cement mortar Ordinary Portland cement

Table 5: Results for Cement Mortar by Using OPC

Sl.No	% replacement ofnano silica	Descri-ption	3 days	7 days	14 days	28 days
1	0	P.C	11.9	16.5	23.5	29.4
2	1.5	$nSiO_2$	12.1	16.8	24.6	30.7
3	**3.5**	**$nSiO_2$**	**12.9**	**17.3**	**26.9**	**31.6**
4	5.5	$nSiO_2$	12.7	15.9	24.9	28.6
5	7.5	$nSiO_2$	10.6	15.6	22.8	28.7

3.2 Cement Mortar Blended Cement

Table 6: Results for cement mortar by using Blended Cement

Sl.No	% replacement ofnano silica	Description	3 days	7 days	14 days	28 days
1	0	P.C	12.5	16.9	24.1	29.9
2	1.5	$nSiO_2$	12.7	18.6	26.8	32
3	**3.5**	**$nSiO_2$**	**13.9**	**19.8**	**27.9**	**33.5**
4	5.5	$nSiO_2$	13.1	17.9	23.4	31.2
5	7.5	$nSiO_2$	11.5	16.8	22.8	28.6

3.3 Compressive Strength for concrete cubes

Table 7: Compressive strength results for concrete cubes by using OPC

Sl.No	% replacement of nano silica	Description	3 days	7 days	14 days	28 days
1	0	P.C	12.5	16.8	21	30.4
2	1.5	$nSiO_2$	13.0	17.6	22.5	31.9
3	**3.5**	**$nSiO_2$**	**14.8**	**18.3**	**23.6**	**32.6**
4	5.5	$nSiO_2$	13.9	17.9	21.6	30.6
5	7.5	$nSiO_2$	13.8	17.0	20.0	29.8

Table 8: Compressive strength results for concrete cubes by using Blended Cement

Sl.No	% replacement of nano silica	Description	3 days	7 days	14 days	28 days
1	0	P.C	12.7	17.4	22.8	30.6
2	1.5	$nSiO_2$	14.1	17.8	23.6	32.4
3	**3.5**	**$nSiO_2$**	**16.2**	**19.7**	**25.3**	**33.6**
4	5.5	$nSiO_2$	15.8	18.6	23.7	31.7
5	7.5	$nSiO_2$	14	17.4	22.6	30.9

3.4 SPLIT TENSILE TEST

Table 9: Split tensile test results for cylinders by using OPC

Sl. No	% replacement of nano silica	Description	3 days	7 days	14 days	28 days
1	0	P.C	1.87	2.47	2.63	3.4
2	1.5	$nSiO_2$	1.93	2.53	2.73	3.67
3	**3.5**	**$nSiO_2$**	**2.2**	**2.87**	**3.13**	**3.7**
4	5.5	$nSiO_2$	1.93	2.63	2.83	3.63
5	7.5	$nSiO_2$	1.7	2.03	2.83	3.16

Table 10: Split tensile test result for cylinders by using Blended cement

Sl. No	% replacement of nano silica	Description	3 days	7 days	14 days	28 days
1	0	P.C	2.2	2.7	3.2	3.7
2	1.5	$nSiO_2$	2.3	2.8	3.3	3.9
3	**3.5**	**$nSiO_2$**	**2.5**	**3.0**	**3.6**	**4.1**
4	5.5	$nSiO_2$	2.1	2.8	3.4	3.8
5	7.5	$nSiO_2$	2.0	2.8	3.3	3.7

3.5 Comparison of cement mortar for OPC and Blended cement

Table 11. Comparison of cement mortar by using OPC and Blended cement

% Replacement of nano silica	OPC				Blended Cement			
	3 Days	7 days	14 days	28 days	3 days	7 days	14 days	28 days
0	11.9	16.5	23.5	29.4	12.5	16.9	24.1	29.9
1.5	12.1	16.8	24.6	30.7	12.7	18.6	26.8	32
3.5	12.9	17.3	26.9	31.6	13.9	19.8	27.9	33.5
5.5	12.7	15.9	24.9	28.6	13.1	17.9	23.4	31.2
7.5	10.6	15.6	22.8	28.7	11.5	16.8	22.8	28.6

3.6 Comparison of concrete cubes by using OPC and Blended cement:

Table 12: Comparison of concrete cubes by using OPC and Blended cement

% Replacement of nano silica	OPC				Blended Cement			
	3 days	7 days	14 days	28 days	3 days	7 days	14 days	28 days
0	12.5	16.8	21	30.4	12.7	17.4	22.8	30.6
1.5	13	17.6	22.5	31.9	14.1	17.8	23.6	32.4
3.5	**14.8**	**15.3**	**23.6**	**32.6**	**16.2**	**19.7**	**25.3**	**33.6**
5.5	13.9	17.9	21.6	30.6	15.8	18.6	23.7	31.7
7.5	13.8	17	20	29.8	14	17.4	22.6	30.9

3.7 Comparison of Cylinders by using OPC and Blended Cement:

Table 13: Comparison of cylinders by using OPC and Blended Cement

% Replacement of nano silica	OPC				Blended cement			
	3 days	7 days	14 days	28 days	3 days	7 days	14 days	28 days
0	1.87	2.47	2.63	3.4	2.2	2.7	3.2	3.7
1.5	1.93	2.53	2.73	3.67	2.3	2.8	3.3	3.9
3.5	**2.2**	**2.87**	**3.13**	**3.7**	**2.5**	**3.0**	**3.6**	**4.1**
5.5	1.93	2.63	2.83	3.63	2.1	2.8	3.4	3.8
7.5	1.7	2.03	2.83	3.16	2.0	2.8	3.3	3.7

4. CONCLUSIONS

The objective of this study is to determine the strength of the materials by using the nano silica and also comparison with the Ordinary Portland Cement and blended cement for the cement mortar. Analyzing the results obtained from this investigation, the following conclusions are drawn.

[1] The compressive strength of the OPC cement mortar is lower than the Blended cement mortar.

[2] The strength will increase by using the increase percentage of the nanosilica.

[3] Upto 3.5% replacement of nanosilica should increase the strength and at 5.5% and 7.5% of silica replacement decreases the strength.

[4] Compressive strength increases with increasing the nanosilica contentupto the 3.5% of replacement by weight of the cement.

[5] The consistency and setting time is different for the percentage increase of $Nsio_2$.

[6] To optimize the performance of nanosilica in OPC and Blended Cement.

[7]Based on the mechanical properties results it can conclude that nanosilica can improve the mechanical properties strength.

5. REFERENCES

[1] **AlirezaNajiGivi, Suraya Abdul Rashid, Farah Nora A. Aziz** - Experimental investigation of the size effects of SiO_2nano-particles on the mechanical properties of binary blended concrete, 2010 Elsevier Ltd.

[2]**Maheswaran.s., Bhuvaneswari** – influence of nano silica in concrete by conducting compressive strength of mortar, Elsevier Ltd.Vol 2,2012.

[3]**AbolfazlShamsai, Saberperoti** – investigate the important parameter water cement ratio on abrasive strength and porosity of nano silica,2012.

[4] **Majid Monshizadeh, MasoudRajabi, Mohammad Hossein Ahmadi, VahidMohammadi** - Synthesis and characterization of nano SiO_2 from rice husk ash by Precipitation method.

[5] **DenniAsraAwizar, NorinsanKamil Othman,AzmanJalar** - Nanosilicate extraction from rice husk ash as green corrosion inhibitor,Int. J. Electrochem. Sci., 8 (2013) 1759 – 1769.

[6] **M.J. Pellegrini-Cervantes, F. Almeraya-Calderon, A. Borunda-Terrazas , R.G. Bautista-Margulis** -Corrosion resistance, porosity and strength of blended portland cement mortar containing rice husk ash and nano-SiO_2 ,J. Electrochem. Sci., 8 (2013) 10697 – 10710.

[7] **S.Maheswaran ,B.Bhuvaneshwari, G.S.Palani, R.NageshIyer and S. Kalaiselvam**- An overview on the influence of nano silica in Concrete and a research initiative,Research Journal of Recent Sciences Vol. 2(ISC-2012), 17-24 (2013).

[8] **S.Tanveer Hussain, K.V.S.Gopala Krishna Sastry** - Study of strength properties of concrete by using micro silica and nano silica(2014).

[9] **K.V.Priya, D.Vinutha**- Effect of nano silica in rice husk ash concrete, ISSN: 2278-1684, p-ISSN: 2320-334X(2014).

[10] **M. Iyappan, A. Jaganadhan** – High strength self compacting concrete with nano silica Issue 4, Vol.5 (Aug. - Sep. 2014).

[11] **Sathyajit parade** – Effect of nano silica on compressive strength of concrete (2014).

[12] **DariushHajizadeh**- Application of nano silica in concrete to improves its mechanical properties and durability,International Journal of Recent Scientific Research Vol. 7, Issue, 6, pp. 12251-12254, June, 2014 .

[13] **Dibyendu Adak, Sari Manual** – Effect of nano silica onstrength of fly ash based geo polymer,2014.

[14] **R. Yu, P. Spiesz, H.J.H. Brouwers** -Effect of nano-silica on the hydration and microstructure development of Ultra-High Performance Concrete (UHPC) with a low binder amount 2014 Elsevier Ltd.

[15]**Arshdeep Singh, Roshan Lal, Pankaj Bavoria, AbhinavSaklani** – Compressive strength of concrete with flyash, nano silica and recycled aggregate(2015).

[16] **Satyajit Parade-** Effect of nano silica on the compressive strength of concrete(2015)**.**

[17]**Paratibha Aggarwal**-Usage of nano silica on in cement based material,effect of nano silica addition on mechanical and durability properties,2015.

[18] **D.V.Prasada Rao** – Study the effect of nano silica containing metakaolin,2016.

[19**]** **DarishHajizadeh** – Study the application of nano silica in concrete,2016.