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THE EFFECT OF ZINC OXIDE NANO-PARTICLE ON COMPRESSIVE STRENGTH OF CEMENT MORTAR

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ABSTRACT:

Nanotechnology, the latest investigation fields that has become popular worldwide from coming days swiftly rising concern in using nanoparticles in cement concrete. Nanoparticles leads to more chemical reaction at the interface, which results in enhanced properties.

Nanoparticles of ZNo with 50-60 nm is investigated. The purpose of this investigation is to prepare a Cement mortar improved mechanical properties

The mortar is used in this study consists of Portland Pozzolana cement (PPC) and nano zinc oxide particles. Binding material (Cement) moderately substituted by Nano Zinc oxide (NZnO). Mortar is mixed with cement as 1:2 & 1:3 and the water – binder ratio of 0.35.

The compressive strength for M-40 Grade of cement mortar is obtained at 7,14,28 days in this study. It For A1 has attained 65% of initial strength within 7 days, further the same mix of 90% of intermediate strength obtained within 14 days duration and also overall 9.24% of total strength achieved by adding 0.50% of Nano-Particles as replacement of cement.

From beyond 1.50% of replacement of Nano- Particles the strength consecutively reducing due to water-cement ratio, pore filling, microstructure interaction and cement paste, etc. And28 days 1:2 mix mortar gained 17.27% of enhancement while 1:3 mix mortar gained only 7.59% strength enhancement.

KEYWORDS: Cement mortar, NZnO, Portland Pozzolana cement and compressive strength.

INTRODUCTION:

Cement is very most useful material for construction. The Production carbon emissions takes place while producing the cement.. Some alternative replacement for binding material can be adopted to minimize global warming. So that extra cement is not required for concrete of higher strength. From this the efficient use of cement will maintain the sustainability of construction. (ZnO) can be used, It is a white solid inorganic substance that is thermally stable, nontoxic and is compatible one. It improves the durability, strength of construction components, safety and energy efficiency.

LITERATURE REVIEW

Several investigators done the investigations on the properties containing nanoparticles. Albashir M. Hashimet.al [2 containing nano zinc oxide.The compressive strength increased upto 23.12% and 61.35% respectively at 3% NZnO in 1:2 mix mortars. Faiz U.A. Shaikh et.al [3], worked on CaCO3 improve the properties of concrete and mortar.

Result shows that at 1% nano-CaCO 3 exhibited highest compressivestrength up to 18%. SupitAliNazariet.al [4], investigated influence of NP in blended concrete, increased upto 15.48%. Rahmat Madandoustet.al[5],have done experiments on SCC nano-SiO2 15.05% at 4% nanoSiO 2 and nano Fe2O3 11.65% at 2% nano. MeralOltuluet.al [6] have sone investigation by replacing nano particles upto 27% in replacement. Ehsan Mohseniet.al[7], have worked on flyash, results shows that upto 11.11% at 3% NSiO 2 and 18.91% at 1% of NAl 2 O 3 and 16.21% at 5% of nano-TiO 2 and water absorption was increased at 5% NSiO 2 at 5% of absorption was decreased at 5% of nano-TiO 2 .Nivethitha.D,et.al[8], investigated influence of ZnO nanoparticle durability of cement mortar, result show that upto 23.88 at 3% NZnO in 1:1 cement mortarand Percentage of water absorption was 3.24 in 1:1 cement mortar at 3% NZnO.

MATERIAL USED AND ITS PROPERTIES:

Portland Pozzolana cement (PPC), Nanoparticle zinc oxide, River sand, Fairflo (super plasticizer).

3.1 Properties of materials:

3.1.1Cement: Portland Pozzolana cement (PPC) IS 1489-1991[9] utilized.

The experiments on cement to know the consistency, setting property and fineness modulus are given in table 1.

TABLE-1 PRELIMINARY TESTS ON PROPERTIES OF CEMENT

S. No.	Properties	Results	Standard IS Code	Range of values
1.	Consistency	32%	IS 1489-1991[9]	-
2.	Initial setting time	120 min	IS 1489-1991[9]	Minimum 30 Minutes
3.	Final setting time	160 min	IS 1489-1991[9]	Maximum 600 Minutes
4.	Specific gravity	3.01	IS2386-1968[10]	2.0-3.0
5.	Fineness modulus	3.66%	IS2386-1968[10]	-

3.1.2River sand: River sand of particle size between 4.75 mm to 150 microns is used as zone-II confirming from the IS: 383-1970[11]. Those properties shown in table-2.

TABLE 2 PRELIMINARY TESTS ON PROPERTIES OF FINE AGGREGATE

S.No.	Properties	Result	Standard IS Code	Range of values
1.	Fineness modulus	3.37	IS2386-1968[10]	2.0 – 4.0
2.	Specific gravity	2.54	IS2386-1968[10]	2.5 - 3.0
3.	Water absorption	0.59%	IS2386-1968[10]	0.3% - 2.5%

3.1.3Nanoparticle Zinc oxide: NZnO with average particle size of 50-60 nm is used in this study. Standard size of nanoparticle should be between 1nm – 100 nm. Properties of NZnO is shown in table3

TABLE 3PROPERTIES OF NZnO

Average particle size (nm)	Specific surface area (m^2/g)	Density (g/cm^3)	Purity (%)	Colour
50-60	16.5	0.31	98%	White

1.1.4 Fairflo SP-40: Fairflo super plasticizer is used in this study. This Super Plasticizer helps to increase the setting time and also added to all mix by 1% of weight of cement. Properties of plasticizer is shown in table 4.

TABLE 4 PROPERTIES OF SUPER PLASTICIZER

Colour	State of SP	Specific Gravity
Dark Brown	Liquid	1.22

2.1.5 Water: In this investigation, ordinary potable water conforming to IS 3025-1986[12] is utilized.

MIXDESIGN:

The mix proportion of traditional mortar and blended mortar were prepared with different binder /sand ratio of 1:2 and 1:3, the ratio of water to binder ratio was fixed at 0.35. In this studythe percentage of NanoParticle (NP) were used at 0.5%, 1%, and 1.5% by weight of cement. The Mix design of the concrete is done as per IS 10262-2009[13].

TABLE 5DESIGN MIX PROPORTIONS FOR MORTAR (1:2) RATIO

Sample	Description of mortar	W/B ratio	Cement	Sand
Control(A)	Conventional mortar	0.45	1	2
$NZ_{0.5}(A_1)$	0.5% cement replacement by NZnO	0.45	0.95	2
$NZ_1(A_2)$	1% cement replacement by NZnO	0.45	0.9	2
$NZ_{1.5}(A_3)$	1.5% cement replacement by NZnO	0.45	0.85	2

TABLE 6 DESIGN MIX PROPORTION FOR MORTAR OF (1:3) RATIO

Sample	Description of mortar	W/B ratio	Cement	Sand
Control (B)	Conventional mortar	0.55	1	3
$NZ_{0.5}(B_1)$	0.5% cement replacement by NZnO	0.55	0.95	3
$NZ_1(B_2)$	1% cement replacement by NZnO	0.55	0.9	3
$NZ_{1.5}(B_3)$	1.5% cement replacement by NZnO	0.55	0.85	3

METHODOLOGY AND EXPERIMENTS:

5.1 Testing procedure: Cement with partially replaced by NZnO is used in the blended mortar mix design. Due to large surface energy of nanoparticlesequal disperse may not be easy. Initially the cement, Sand, NZnO, Super plasticizer were weighted accurately. The mixing was performed manually by ultrasonic water bath for period of 1-minute as per IS 2250-1981. The mortar cube specimens of size 70.5 mm x 70.5 mm x 70.5 mm were used. Total 72 specimens are casted and kept in curing for period of 7, 14 and 28 days as shown in Fig.1 Cubes are tested by using compression testing machine apparatus. The tests are conducted according to IS 516-1959 or ASTM C109[14].

Fig 1 Immersion of cube specimens.

RESULTS AND DISCUSSIONS:

5.1 Compressive Strength: Results of compressive strength are determined after 7, 14 and 28 days from the detailed experimental study are shown in table-7.

(A) The Cement mortar containing 0.5%, 1% and 1.5% of nanoparticle increases the strength of blended mortar compare to conventional mortar for 1:2 mix design.

(B) In the case of 1:3 mix mortar the strength at 7, 14 and 28 days increases upto 1% ZnO nanoparticles and decreases the strength at 1.5% of NZnO.

(C) The strengths for mix of 1:2 at NZ1.5 (A3)for a period of 7 days is 29.06MPa, at 14days 40.20MPa and at 28days is 44.80MPa.

(D) The strengths for mix of 1:2 at NZ1.0 (A2) for a period of 7 days is 28.33MPa, at 14days 38.46MPa and at 28days is 42.80MPa.

(E) The strengths for mix of 1:2 at NZ0.5 (A1)for a period of 7 days is 27.46MPa, at 14days 37.56MPa and at 28days is 41.73MPa.

(F) The normal strength values for mix of 1:2 (A) are 24.33MPa, 34.33MPa and 38.20MPa at 7 days, 14 days and 28 days respectively.

(G) The strengths for mix of 1:3 at NZ1.5(B3) for a period of 7 days is 18.86MPa, at 14days 25.66MPa and at 28days is 29.53MPa.

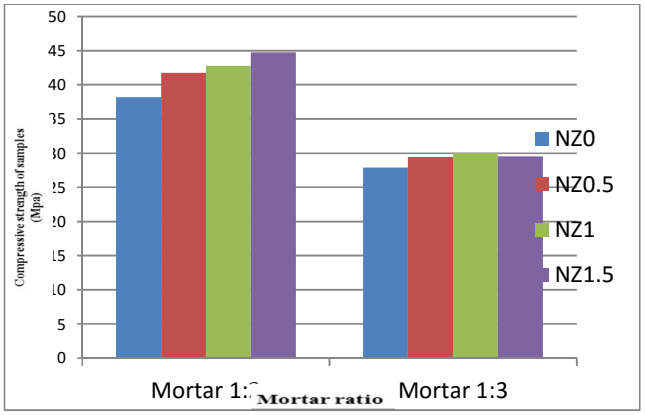
(H) The strengths for mix of 1:3 at NZ1.0(B2) for a period of 7 days is 19.46MPa, at 14days 26MPa and at 28days is 30.05MPa.

(I) The strengths for mix of 1:3 at NZ0.5(B1)for a period of 7 days is 19.33MPa, at 14days 26.40MPa and at 28days is 29.46MPa.

(J) The normal strength values for mix of 1:3 (B)are 18.13MPa, 24.46MPa and 27.93MPa at 7 days, 14 days and 28 days respectively.

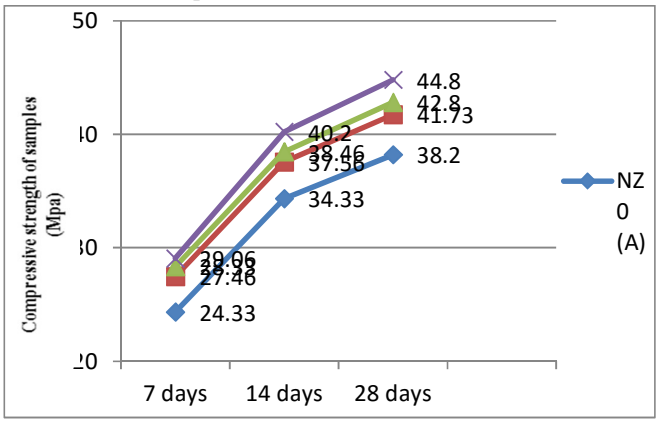
TABLE 7 COMPRESSIVE STRENGTH OF CEMENT MORTARS WITH VARIOUS CURING PERIODS

Sample Type	Compressive strength of Cement mortar (MPa) with various curing periods			
	7 days	14 days	28 days	% of enhancement
A	24.33	34.33	38.20	-
B	18.13	24.46	27.93	-
A_1	27.46	37.56	41.73	9.24
A_2	28.33	38.46	42.80	12.04
A_3	29.06	40.20	44.80	17.27
B_1	19.33	26.40	29.46	5.42
B_2	19.46	26	30.05	7.59
B_3	18.86	25.66	29.53	5.72



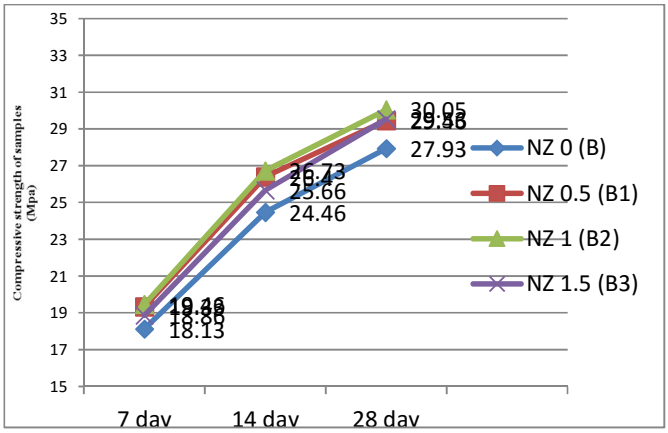
Plot-1 28-days Compressive strength ratio of cement mortars with respect to Nanoparticles

From plot-1, it is observed the mix 1:2 is having relatively values than the mortar mix 1:3. From mix 1:2 NZ1.5 have high strength 44.80MPa where as in mix 1:3 NZ1.0 having high strength which is 30.05MPa.The strength in 1:2 mix consecutively increasing while in mix 1:3 the strength decreases after 1% replacement of nano particles this is due to water cement ratio, inter-molecular forces between nano particles.



Plot-2 Typical compressive strength curve of cement mortar 1:2

From Plot 2, it is observed that the increase in NZ1.5.It may be due to the reaction between Nano Zinc Oxide and cement constituents, the nano particles will increase the strength at micro structure level and at the same time it will reduce the workability. To increase the workability, we will use super Plasticizer hence overall performance will be improved.



Plot-3 Typical compressive strength curve of cement mortar 1:3

From Plot-3, it is observed that there is icrease in NZ1.0 and beyond 1% replacement decreasing. This is due to interaction between the nano particles, decreased quantity of cement with respect to sand water cement ratio

CONCLUSIONS:

1) It is observed that NZnO particle improve the strength of blended mortar.
2) The strength of mortar mix 1:2 at 1.5% NZnO strength increases by 17.27% and for mortar mix ratio 1:3 at 1% NZnO strength increases by 7.59% i.e. higher than normal cement mortar. Ehsan Mohseniet.al states that durability of blended mortar also improved by adding nano-particles and nano particles can act as a filler to enhance the density of concrete, which reduces to the porosity of concrete being significantly
3) Zinc Oxide increases the strength, Nano-ZnO particles added to the binding but the use of super plasticizer is essential.
4) From the previous authors it is proved that nano particles will improve the rheological and thermal properties of cement mortar.

FUTURE SCOPE OF THE STUDY:

The slight reduction in the workability of cement mortar mixes indicates that the nano particle replacement and processing technology in India need to be improved in order to produce good and acceptable quality of cement mortar. There is no processing facilities available to ensure the quality, as in countries abroad. Extensive experimental work is required to establish how the properties of mortar like compressive strength, strength gain, shrinkage, etc. are affected in aggressive condition with properties of nano materials and the deleterious effects on long time durability of mortar.

REFERENCES:

1) Albashir M. Hashim, G. AlseedHashimandAbdalmajed Rabab, "Mechanical Properties of cementitious composite by using ZnO nanoparticles", Journal of Research in Applied Science and Engineering Volume 4 Issue X (2016) 2321-9653.
2) Arefi Mohammad Reza and Rezaei Saeed, "Synthesis of Zinc Oxide Nanoparticles and Their Effect on the Compressive Strength and Setting Time of Self Compacted Concrete Paste asCementitious Composites", Journal of Molecular Science (2012) 4340–4350.
3) Ashe Barnali, "A detatil investigation to observe the effect of Zinc oxide and silver nanoparticles in biological system" (2011).
4) Ghafari E.,Ghahari S.A., Feng Y.,Severgnini F., and N. Lu, "Effect of Zinc oxide and Al-Zinc oxide nanoparticles on the rheological properties of cement paste", Journal of Composites Part B 105 (2016) 160-166.
5) Hui Li et.al, "Microstructure of cement mortar with nano-particles"Journal of Composite: part B 35 (2004) 185-189.
6) MeralOltuluet.al MadandoustRahmat, and Mohseni Ehsan, "An experimental investigation on the durability of self-compacting mortar containing nano-SiO_2, nano-Fe_2O_3 and nano-CuO", Journal of Construction and Building Materials 86 (2015) 44-50.
7) Mohseni Ehsan, "Single and combined effects of nano-SiO_2, nano-Al_2O_3 and nano-TiO_2 onthe mechanical, rheological and durability properties of self-compacting mortar containing fly ash", Journal of Construction and Building Materials 84 (2015) 331-340.
8) Nazari Ali, ShadiRiahi, ShirinRiahi, SeyedehFatemehShamekhi and A. Khademno, "Investigate the compressive strength and workability of concrete by

partial replacement of cement with nano-phase Fe_2O_3 particles", Journal of American Science 2010;6(4):102-106.

9) NazariAli andRiahiShadi, "The Effects of ZnO2 nanoparticles on strengthAssessments and water permeability of concrete in different curing media", Journal of material research vol. 14 (2011).
10) Nivethitha D. and Dharmar S., "Effect of Zinc Oxide Nanoparticle on Strength ofCement Mortar", International Journal of Science Technology & Engineering Volume 3 Issue 05 (2016).
11) Nivethitha D.,Srividhya S., and Dharmar S., " Review on Mechanical Properties of Cement Mortar Enhanced with Nanoparticles such as nano-SiO2, nano-Fe2O3, nano-Al2O3, nano- CuO, nano-TiO2", International Journal of Science and Research Volume 5 Issue 1 (2016).
12) OlarRadu, "The use of nanomaterials in the various fields such as medicine, construction, automobile industry, energy", project research (2011).
13) Patil Jitendra, and Dr. Pendharkar Umesh, "Study of Effect of Nanomaterials as Cement Replacement on Physical Properties of Concrete", International Research Journal of Engineering and Technology Volume: 03 Issue: 01 (2016).