

# Effect on Quality of Cement-Mortar by Inclusion of Nano Particle of Zinc Oxide

Avinash Birthare, Mukesh Pandey, Sohit Agarwal



**Abstract:** Now days, there are so many new nano-technologies and methodologies are developed on the field of construction. These days, there is a swiftly rising concern especially using Nano-particles in Portland Pozzolana cement (PPC) concrete to improve the overall properties. The upper layer area of Nano-particles gives more chemical reaction at the subject to gives improved properties and capacities. Complete experiment the mixture of PPC- mortar with Nano-particles, ZnO with diameter of 50-60 nm of compressive-strength are investigated. ZnO have good physical and chemical properties such as dissolve in most of acids, reducing void ratio, availability in different crystalline forms gives enhanced mix of mortar. The principle reason for this investigation prepare a blended mortar with improved mechanical properties. The impacts of nano particles on the qualities such as compressive strength of mortar were experimentally investigated. The blended cement consists of Portland Pozzolana cement (PPC) and nano zinc oxide (NZnO) particles are used. The blended cement given in this investigation consists of Por PPC-cement and NZnO particles. The cement is moderately replaced with NZnO of 0, 0.5, 1, and 1.5 % by PPC cement. The mixture of cement, sand and water was prepared by the ratio of 1:2 and 1:3 of cement-sand by weight with water – binder ratio of 0.35. The strength of cement mortar will be measured after 7, 14 and 28 days.

By adding NZnO, we can get good strength values of concrete more than usual strength values we got approximately 18%, of more strength by replacing 1.5% of cement by weight and also there is minimum usage of water with using super plasticizer.

**Keywords:** Cement mortar, ZnO nano-particle, and compressive strength property, PPC- Portland Pozzolana cement.

## I. INTRODUCTION

Concrete is the root of material in the construction mostly utilized in construction works it consist of cement, aggregate (fine & coarse) and sufficient amount of water. The cement is the most important glue for mortar mix. Cement is the necessary material to form the mortar. Production of cement causes pollution. Efforts are made to produce high strength concrete without increasing cement by incorporating Nano materials such as oxide zinc, titanium dioxide, calcium carbonate and Nano silica etc so that extra cement is not required for the creation of concrete of higher strength. This is the efficient use of cement and will maintain the sustainability of construction as well.

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Zinc oxide (ZnO) is a white solid inorganic substance that is thermally stable, non poisonous and suitable with humane skin and also suitable for textiles and outer layers may interact with human body according to the research of Barnali Ashe [3]. Nano particles also works as heterogeneous cores for concrete glues further quicking concrete hydration, due to their great reactive nature , as a nano-reinforcement, and as a nano-filling material, concrete the structure with high density, making the micro-structure denser, in this way it will minimum porosity. An experiment has been done to show that utilizing ZnO nano particles, it is feasible to yet blended mortar with improve properties. Several investigations have shown that NZnO improves the mechanical properties and reduces the porosity of cement mortar and concrete. In this experiment result improves the durability and strength of construction components, safety of the buildings, energy efficiency.

## II. LITERATURE REVIEW:

Several investigators done a study on overall property of cement concrete mixed with several nano-particles. D. Nivethithha and dharmar et.al [1], studied the compressive strength of cement mortar containing nano zinc oxide. From the calculation the strength values was increased up-to 23.12% and 61.35% respectively at 3% NZnO in 1:2 mix mortar. Faiz U.A. Shaikh and Steve W.M. et.al [2], have worked on calcium carbonate (CaCO<sub>3</sub>) nanoparticles and increase the mechanical and durable aspects concrete and mortar. Result show that at 1% nano-CaCO<sub>3</sub> exhibits highest compressive strength up to 18% at 28 days in cement mortar. Supit Ali Nazari et al [3], investigated influence of Fe<sub>2</sub>O<sub>3</sub> in terms of compressive strength values of blended concrete as nanoparticle, result show that compressive strength was increased upto 15.48% at 1% Fe<sub>2</sub>O<sub>3</sub>. Rahmat Madandoust et.al [4], have proved the presence of nanoparticles also improved the properties of self-compacting mortar containing such as nano-SiO<sub>2</sub> improved compressive strength up to 15.05% at 4% nano SiO<sub>2</sub>, and nano Fe<sub>2</sub>O<sub>3</sub> improved the compressive strength up to 11.65% at 2% nano Fe<sub>2</sub>O<sub>3</sub> and nano-CuO improved the compressive strength up to 16.39% at 3% nano CuO. Meral Oltulu et.al [5], have experimented independently studied the effect of adding nano-(SiO<sub>2</sub>,Al<sub>2</sub>O<sub>3</sub>) and nano-Fe<sub>2</sub>O<sub>3</sub> to mixture containing silica fume increased the compressive strength upto 27%. Ehsan Mohseni et.al [6], studied on out-come of nano-SiO<sub>2</sub>, nano-Al<sub>2</sub>O<sub>3</sub> and nano-TiO<sub>2</sub> in all independently and merging of these nanoparticles on the different aspect of self compacting mortar with contain with fly ash, result show that increasing the compressive strength upto 11.11% at 3% of nano-SiO<sub>2</sub> and 18.91% at 1% of nano-Al<sub>2</sub>O<sub>3</sub> and 16.21% at 5% of nano-TiO<sub>2</sub> and water absorption was increased at 5% of nano-SiO<sub>2</sub> and and at 5% of nano-Al<sub>2</sub>O<sub>3</sub> and water absorption was decreased at 5% of nano-TiO<sub>2</sub>.

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D nivethithha and dharmar et.al [7], investigated influence of ZnO on the strength values and durable properties of cement mortar, result show that compressive strength was increased upto 23.88 at 3% NZnO in 1:1 cement mortar and % of water absorption was 3.24 in 1:1 cement mortar at 3% NZnO.

### III. PROPERTIES OF MATERIAL USED:

The following material are used such as Portland Pozzolana cement (PPC), Nano-particle zinc oxide (NP), River sand, Fairflo (super plasticizer).

#### A. Cement

Portland Pozzolana cement (PPC) is used, Various test are done on cement such as specific gravity, fineness modulus, consistency test, setting time (initial & setting) and consistency test of cement the obtained values of the above test result given in table-I.

Table- I: Properties of cement

Sr. No.	Properties	Results
1	Consistency	33 %
2	Initial setting time	45 min
3	Final setting time	165 Min
4	Specific Gravity	3.17
5	Fineness Modulus	2.9

#### B. River sand

Particle (4.75 mm to 150 micron) size of aggregate are called as fine aggregate. River sand is used of zone-II confirming from the IS: 383-1970. That property shown in table-II.

Table- II: Properties of Fine aggregate

Sr. No.	Properties	Results
1	Fineness Modulus	3.42
2	Specific Gravity	2.52
3	Water Absorption	0.72 %

#### C. Nano-particle Zinc oxide

Average size of particles 50-60 nm are utilized in this investigation. As per the standardization nano-particle should be between 1nm – 100 nm. Properties of NZnO is given in table-III

Table- III: Properties of Nano-Particle.

Average Particle Size (Nm)	Specific surface area (m <sup>2</sup> /g)	Density (g/cm <sup>3</sup> )	Purity (%)	colour
50-60	17	0.30	99%	White

#### D. Fairflo SP-40

Fairflo super plasticizer it is used for reducing water in mixture. Properties of plasticizer are colour; Dark Brown, Type; Liquid, specific gravity 1.21.

### IV. MIX PROPORTIONS

Two different type of mortar were prepared with cement sand ratio 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 study the percentage of nano-particle were used at 0.5%, 1%, and 1.5% by weight of cement.

#### Sample

The blended mortar mix was prepared by mixing cement, sand and nano-particle of zinc oxide. prepare mixing the materials the paste was filled in cube moulds of size ( 70.6 x 70.6 x 70.6) mm. and removed these cubes after 24 hr. and put-down into water tank for curing up to 7,14,and 28 days.

### V. METHODOLOGY AND EXPERIMENTS

#### Testing Procedure

PPC-Cement with partially replacement by nano-particle zinc oxide is used in the blended mortar mix design. Due to larged surface energy of nano-particles are not easy to equally disperse. Thus there is a pro-farmed for mixing of nano-particles. that is the NZnO particles and super-plasticizer were mixed with water in the ultrasonic water bath for 1 minute. Adding cement with this mixture and mixed properly. The mixed of fine aggregate is added progressively and mixed the material properly upto 3-4 min then the mortar was filled in to the standard mould. The mortar cube specimen of size ( 70.6 x 70.6 x 70.6) mm testing cube were used for compressive and durability test. Nine specimens of each type for compressive strength test were prepared and all cube sample are placed in curing process in water tank for 07, 14 and final 28 days. Compressive strength determination is to be done in according to ASTM C109.

Table- IV: Mix Design Ratio (1:2) for Mortar

Sample	Description of Mortar	Water/Bind ratio	Cement	Sand	NP	SP % of cement
Control (A)	Conventional mortar	0.35	1	2	-	1
NanoZinc <sub>0.5</sub> (A <sub>1</sub> )	0.5% cement replacement by NZnO	0.35	0.95	2	0.05	1
NanoZinc <sub>1</sub> (A <sub>2</sub> )	1% cement replacement by NZnO	0.35	0.9	2	0.1	1

NanoZinc <sub>1.5</sub> (A <sub>3</sub> )	1.5% cement replacement by NZnO	0.35	0.85	2	0.15	1
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Table- V: Mix Design Ratio (1:3) for Mortar

Sample	Description of Mortar	Water/Bind ratio	Cement	Sand	NP	SP % of cement
Control (B)	Conventional mortar	0.35	1	3	-	1
NanoZinc <sub>0.5</sub> (B <sub>1</sub> )	0.5% cement replacement by NZnO	0.35	0.95	3	0.05	1
NanoZinc <sub>1</sub> (B <sub>2</sub> )	1% cement replacement by NZnO	0.35	0.9	3	0.1	1
NanoZinc <sub>1.5</sub> (B <sub>3</sub> )	1.5% cement replacement by NZnO	0.35	0.85	3	0.15	1

VI. EXPERIMENT RESULTS AND DISCUSSION

**Compressive Strength:** - The value of compressive strength after 7, 14 and 28 days are shown in table-6. Cement mortar containing 0.5%, 1% and 1.5% of nano-particle increase the compressive strength of blended mortar compare to conventional mortar for 1:2 mix design.

In the case of 1:3 mix mortar the strength at 7, 14 and 28 days increases upto 1% ZnO nano-particles and decreases the compressive strength at 1.5% of NZnO

Table- VI: Compressive strength of mortar (MPa)

Sample type	7 days	14 days	28 days	% of enhancement
A	23.85	34.65	38.62	-
B	19.28	24.58	28.37	-
A <sub>1</sub>	26.56	38.20	42.23	9.34
A <sub>2</sub>	27.20	38.85	43.38	12.32
A <sub>3</sub>	28.74	40.63	45.35	17.42
B <sub>1</sub>	18.24	26.89	30.16	6.30
B <sub>2</sub>	18.95	27.10	30.63	7.96
B <sub>3</sub>	18.64	26.22	30.17	6.34

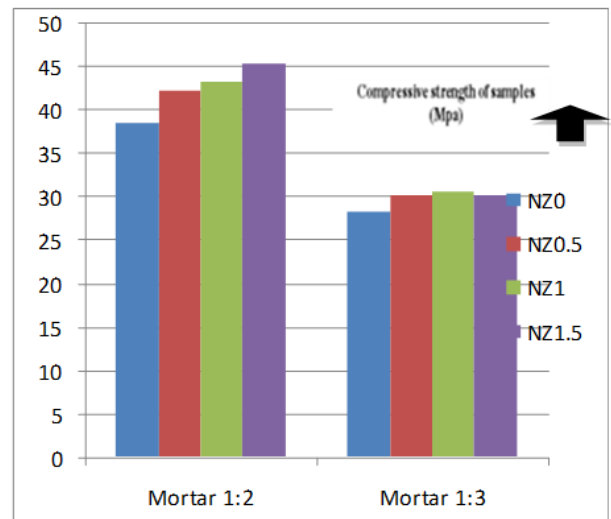


Figure 1: Compressive strength column chart, we can clearly observed that the strength value are more for mortar mix-1:2 than mortar mix 1:3

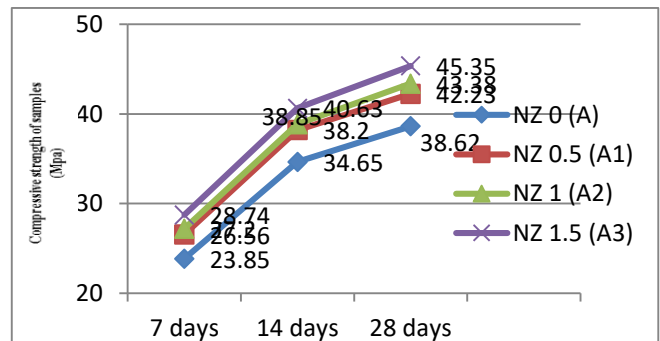
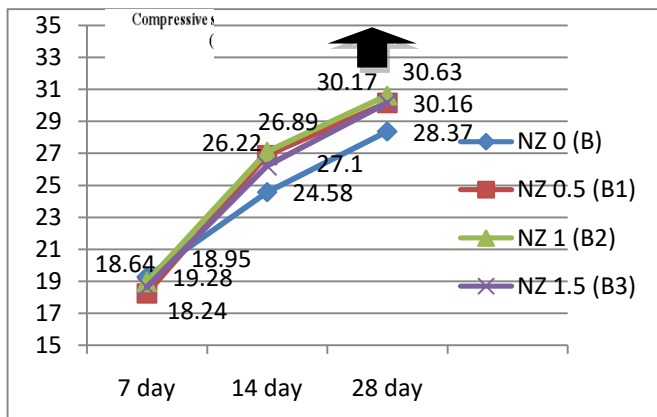


Figure 2: Typical compressive strength curve of cement mortar 1:2 , where no usage of ZnO, we got nominal strength values, that we can see in fig.2

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**Figure 3: Compressive strength curve of cement mortar 1:3**

We got only 30 Mpa compressive strength of concrete by adding 1% of ZnO, this is the maximum value i.e., we got 75% of desired strength.

### VII. CONCLUSION

Based on the experimental result it is observed that NZnO particle improve the compressive strength and durability of blended mortar. The compressive strength of mortar mix 1:2 at 1.5% NZnO compressive strength increases by 17.42 % and for mortar mix ratio 1:3 at 1% NZnO compressive strength increases by 7.96 % i.e. higher than control mortar. Durability of blended mortar also improved. Proved Nano-particles can act as a filler to enhance the density of concrete, which reduces to the porosity of concrete being significantly. ZnO increases the setting time. Nano-ZnO particles added to the binding material is reduces the workability of mortar, therefore the use of super plasticizer is proved to we more effective in terms of strength, durability and also reduces void ratio.

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