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Effect of Zinc Oxide Nanoparticle on Properties of Concrete

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Abstract - *Several mineral and chemical admixtures, commonly used in structural concrete, were studied to assess their effect on the fresh and hardened properties of cementitious systems. Pozzolana examined here is ZnO nanoparticle, while chemical admixtures were air-entrainer, water reducer/retarder and two super plasticizers. The received materials were characterized for their chemical oxide composition, crystalline and amorphous content, density, fineness, specific surface area, and particle size distribution. Several tests were conducted on binary and ternary mixtures to assess the performance of the cementitious system. Additionally, a limited number of investigations are dealing with the manufacture of nano sized cement particles and the development of nano binders.*

The study attempts to evaluate the impact of six different additives, including natural additives and nano-additives in M 40 grade concrete. The test design is adopted on for the mixes and the optimum amount of admixtures are determined for concrete mixes and their performance is analyzed. The experimental work has been carried out by addition of nano ZnO in 0%, 0.2%, 0.5%, and 1% brings to change in properties of the concrete.

Thus the property of mixture can be enhancing on their composition with decrease in weight on ZnO nano concrete. The use of chemical and mineral additives is the most effective way to improve the quality of the concrete, and to give them specific properties.

Key Words: **Chemical admixtures, Zinc Oxide (ZnO), High strength concrete, Pozzolana**

1. INTRODUCTION

With the advancement of nanotechnology, Nano material have been developed that can be applied to concrete mix designs to study the physical, chemical and enhanced mechanical properties of concrete. Nanotechnology is a very active research field and has applications in a number of areas. Now a days Nano materials are used in construction along with the traditional building materials. Incorporation of Nano materials in concrete is a most promising concept for developing concrete having certain desirable properties. The extremely fine size of the particles can alter the specific surface area and hence the properties of concrete. Nano particles added cement composite can increase the workability, strength and durability characteristics.

1.1 Concrete with nano particles

Nano particles can also improve the bond between the aggregates and cement paste. Studies on cement paste with Nano materials are absolutely necessary to understand the influence of Nano materials. Currently this technology is being used for the creation of new materials, devices and systems at molecular, Nano and micro-level. Nano materials show unique physical and chemical properties that can lead to the development of more effective materials than the ones which are currently available. The extremely fine size of Nano-particles yields favourable characteristics. Because of their high surface area and excellent fire retardant properties, Nano particles can be used in construction in many ways. Addition of Nano-materials to cement and concrete can lead to significant improvements in the field of civil engineering.

1.2 Portland Cement with ZnO nano admixture

ZnO added to the system Portland cement water changes the kinetics of the hydration process substantially. Amorphous zinc hydroxide is formed and inhibits the reaction of tricalcium silicate with water, resulting in an induction period prolongation. This effect depends on the amount of ZnO added to the hydrated paste. The transformation of zinc hydroxide into calcium hydrozincate provokes the further hydration.

Fig -1: Sample Zinc Oxide

2. LITERATURE REVIEW

D.Nivethitha et al. (2016), found that the cement could be beneficially replaced with ZnO nano particles up to maximum limit of 3% with average particle sizes of 60 nm. With the increase of ZnO nanoparticle from 3%, the mechanical properties of mortar are slightly decreased. Nano-ZnO particles added to the binding material is declined workability of mortar, consequently the use of super plasticizer is essential. According to the experimental results,

it is possible to add nano-Zinc Oxide particles to improve the compressive and split tensile properties of cement mortar.

Anshul Pathak(2017), investigated mechanical and durability properties of cement concrete having Nano-particle of Zinc Oxide with the particle size of 60 nano meter. The experimental output confirmed that using ZnO Nano particles up to maximum replacement degree of 1.5% produces concrete with enhanced strength. The cement was partially substitute by using Nano ZnO of 0, 0.5, 1, and 1.5 % by using weight of cement. Based on the experimental investigation it was noted that Nano ZnO increases the setting time, Nano-ZnO particles added to the binding material reduces the workability of Concrete, therefore the addition of super plasticizer is essential. NZnO particle improve the compressive strength of concrete by 18% when 1% NZnO is added in concrete. Durability of blended concrete also improved. Nano particles performed as a protective material to improve the density of concrete that decreases the porosity of concrete significantly. When increasing the percentages of NZnO beyond 1% the strength of concrete decreases.

2.1 Aim & Objectives

- To investigate the performance of concrete using Nano Zinc Oxide additive.
- To compare Nano ZnO additive with conventional concrete mixture for the better use ability and to bring low cost in construction.
- To maintain a good indoor environmental quality & performance of the building all through.
- To conduct the compressive test.
- The split tensile test.

3. MATERIALS AND METHODOLOGY

3.1 Materials used

Cement: Ordinary Portland cement of grade 43 is adopted for this work. The brand of cement used was Ultra Tech OPC with grade 43. The cement was gray and free from lumps.

Aggregates: In this research work fine aggregates used was river sand zone II and coarse aggregates used were crushed stones. These materials were easily available from local market.

Nano Zinc Oxide: Zinc oxide is an inorganic compound with the formula ZnO. ZnO is a white powder that is insoluble in water, and it is widely used as an additive in numerous materials. Zinc oxide Nano particle filled cement composite was developed for a new combination of cement mortar with improved strength and durability.

Water: Clean tap water was used for washing aggregates, and mixing and curing of concretes.

3.2 Method Adopted

1. Properties of various constituents of concrete viz,

Cement, fine aggregates, coarse aggregates and Nano ZnO were determined, by carrying out various tests.

2. Grade M40 concrete was designed as per IS: 10262-

2009, which was used as reference mix.

3. Nano Zinc Oxide is added in 0%, 0.2%, 0.5%, and 1% by weight of Cement.

4. Cube and cylinders was casted and curing was done.

5. Compressive strength test, split tensile strength test was done.

4. EXPERIMENTAL PROGRAMME

Mix Proportions for M40 grade of Concrete

Mix Proportions

FOR Zno(0.5%)

Cement = 13.33 kg

ZnO= (0.5% by Total weight of Cement)

Water = 5.766 liter

Fine aggregate(M sand) = 21.297 kg

Coarse aggregate 20mm =35.80 kg

The specimens of standard sizes and required shapes of different mix proportions were casted for 7, 14, 28, days and curing process is carried out after 24hrs from casting time.

5. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

5.1 Slump flow

Slump cone values for Metakaolin concrete mixes are given in table 5.1 below

Sl.no	Type of Samples		Slump(mm)
1	Nominal mix		95
2	Nano ZnO	0.2% 0.5% 1%	98 103 97

Table -5.1: Slump Flow values

5.2 Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days, 14 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Sl.no	Mix (days)		Cube
			Compressive strength (N/mm²)
1	7	OPC	31.3
		0.2%	32.2
		0.5%	33.3
		1%	30.4
2	14	OPC	40.7
		0.2%	41.3
		0.5%	42.8
		1%	40.8
3	28	OPC	48.6
		0.2%	49
		0.5%	51.2
		1%	47.9

Table -5.2: Compressive Strength values

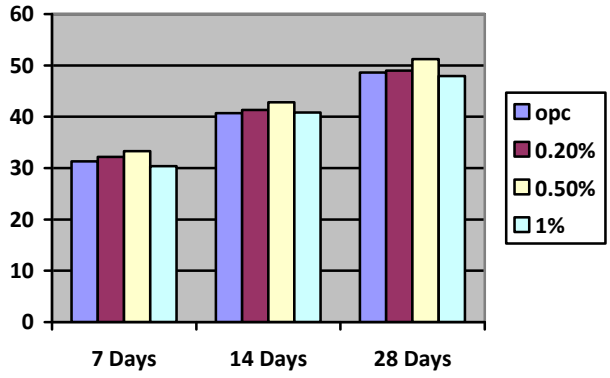

Chart -5.2: Compressive Strength

5.3 Split Tensile Strength

The split tensile test were conducted as per IS 5816:1999. The size of cylinder is 300mm length with 150mm diameter. The specimen were kept in water for curing for 7 days, 14 days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

Sl.no	Mix (days)		Cube
			Compressive strength (N/mm²)
1	7	OPC	3.21
		0.2%	4.02
		0.5%	4.21
		1%	3.92
2	14	OPC	3.82
		0.2%	4.52
		0.5%	4.70
		1%	4.34
3	28	OPC	4.52
		0.2%	5.10
		0.5%	5.29
		1%	4.96

Table -5.3: Split Tensile Strength values

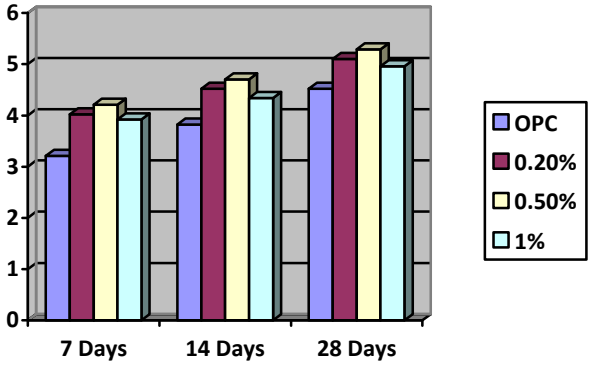

Chart -5.3: Split Tensile Strength

6. SUMMARY AND CONCLUSIONS

The main objective of this study is to analyze the performance of addition of commercially available Nano ZnO as a additive in cementitious materials to avoid void resistance for concrete structures and to increases the mechanical properties. ZnO is readily available and is environment friendly.

The following conclusions were obtained as a result and performance for the tests conducted..

The conventional mix & M40 achieves a compressive strength of 48.6 N/mm2 and Split tensile strength values of 4.52 N/mm2 for 28 days of curing.

A concrete with nano ZnO admixture achieves a compressive strength of 51.2 N/mm2 and Split tensile strength values of 5.19 N/mm2 for 28 days of curing by addition of 0.5% nano ZnO.

It can be understood from the table that the sample having 0.5% ZnO nanoparticles, the mechanical properties of concrete has increased than the traditional concrete. On

further addition of ZnO nanoparticle up to 1%, the strength of concrete reduced.

The ZnO nanoparticle blended concrete had higher split tensile as compared to that of the control experiment. It is found that cement could be advantageously replaced with ZnO nanoparticles and the optimum level of ZnO nanoparticle content was achieved with a 0.5% on addition.

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