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Effect of Zinc Oxide Nanoparticle on Compressive Strength and Durability of Concrete

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Abstract: ***Nanotechnology has changed our imaginative and prescient, expectations and abilities to manage the material industry. The improvements in Nano-technology also can have an extremely good effect on the sector of construction materials. The reason of this experimental analysis is to research the compressive energy and sturdiness of concrete with the aid of addition Nano-particle of zinc oxide. ZnO Nanoparticle fills the pores completely and also quickens the hydration procedure of cement particles, which causes enhance in mechanical strength and durability. The mechanical and durability property were investigated of cement concrete having Nano-particle of Zinc Oxide with the common particle size of 60 nm. 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 NZnO of 0, 0.5, 1, and 1.5 % by using weight of cement. The compressive strength of Concrete cubes cured for 7, 14 and 28 days Durability test of cement Concrete was completed via the use of 10 % of NaCl solution.***

Keywords: ***Nanoparticles, Concrete, Zinc oxide, Strength, Mechanical properties.***

I. INTRODUCTION

The introduction of Nanomaterials in concrete to enhance their mechanical properties has been broadly employed in latest concrete technology. The latest investigation on Nano materials has explained the possible use of these nano particles of ZnO in construction applications. Building materials domain can be one of the primary beneficiaries of this investigation, with applications that will improve the characteristics of concrete, steel, glass and insulating materials. The addition of Nanomaterials within the properties of few substances, inclusive of cement, will cause in major reductions of CO_2 pollution and the use of performance thermal insulations will result in efficient use of energy for air conditioning. Presently, the use of Nano materials in construction is condensed, specifically due to the lack of understanding about the design and implementation of the construction factors the use of Nano-materials. Nanotechnology has changed our imaginative and prescient, expectancies and capabilities to manipulate the material industry. The developments in Nano-science also can have a splendid impact on the field of construction materials. Portland cement, known as primary major development elements consumed by construction, improved understanding and engineering of difficult structure of cement based materials at Nano-level will absolutely effect in a new invention of concrete, more potent and greater strong, with desired stress-stress behavior and, in all likelihood, with the complete variety of newly introduced “smart” properties.

Ali Nazari et.al.[2] analyze the impact of limewater on power evaluation and fraction of water inclusion of concrete material including ZnO2 Nanoparticles. The test output explained that the samples with ZnO2 nano particles have considerably advanced strength with evaluation to that of specimens without nano ZnO2 particles at all stages of curing. D Nivethitha et. al. [4] analyzed the effect of Nano particle of zinc oxide on mortar and find out the Compressive strength. Impact strength of mortar showed significant enhancement by using up to 3% of NZ particle. Dusan Nohavica et. al.[5] they analyze the Zno Nano particle and their effects. E. Ghafari et. al. [6] studied effect of ZnO and Al- zinc nano particles on the material functions of cement mixture and optimized compressive strength and workability. Ehsan mohseni et. al. [7] investigates the use of Nano SiO_2, Nano-AlO_3, and Nano-TiO_2 and their effects on self-compacting mortar using fly ash. Compressive strength increases by 3%. Faiz U. A. Shaikh et. al.[7] optimize strength and stability properties in concrete with high amount of fly ash with $CaCO_3$. The mixing of CaCO3 nanoparticles not only direct that much denser microstructure in HVFA matrix but also changed the arrangement of hydration goods. Akhilesh Pratap Singh et. al. [1] investigates the Nano particle used in cement mortar and test compressive strength found 17.27%.

II. MATERIALS USED

A. Cement

The cement used in this Experimental investigation was PPC. The Tests on cement used are given in Table 1.

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Table1: Test on Cement

Properties	Value
Fineness	2%
Sp. gravity	3.108
Initial setting time	120 min
Final setting time	160 min

B. Fine Aggregate

The river sand was mixed in this investigation as fine aggregates it was free from natural contamination. The zone of fine aggregate was zone II as per IS specifications. The Properties of fine aggregate are given in table 2.

Table 2: Tests on Fine Aggregate

Properties	**Value**
Specific Gravity	2.63
Fineness	2.77
Water absorption	0.61%

C. Coarse Aggregate

Crushed stone of under 20mm size used as coarse aggregates.

Table 3: Properties of Coarse Aggregate

Properties	**Values**
Specific Gravity	2.884
Maximum Size	20mm
Fineness	7.00
Water absorption	0.40%

D. Nanoparticle Zinc oxide

ZnO with average particle size of 50-60 nm were used in this Experimental investigation. When used for concrete production, ZnO enhanced the processing time and the resistances of concrete towards water. physical properties of ZnO are shown in Table4.

Table 4: properties of Nanoparticle

Average particle size (nm)	Specific surface area (m^2/g)	Density (g/cm3)	Purity (%)	Colour
50-60	17	0.30	99%	White

Source: *Sooraj udhyog Pvt. Ltd. New delhi.*

E. Super Plasticizer(Fairflo SP-40)

-Fairflo super plasticizer water reducing mixture is used in this study. Properties of plasticizer are color; Dark Brown, Type; fluid, specific gravity 1.21.

III. EXPERIMENTS AND RESULTS

Cement with additive material Nano-particle zinc oxide is used within the mixed Concrete mix layout. Due to higher floor electricity of Nano-particle aren't simple to similarly disperse. The ZnO particle and Superplasticizer were blended with water in the ultrasonic water bath for 1 minute. Cement changed into added with this aggregate and mixed at medium velocity. the concrete aggregate was filled in to the usual mold. The Concrete dice specimen of length 150 mm x 150 mm x 150 mm changed into used for compressive and durability test. Nine specimens had been prepared every test and all specimen have been cured in water tank for 7,14 and 28 days.

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Table 5: design Mix Proportion for concrete with Zno Nano particles

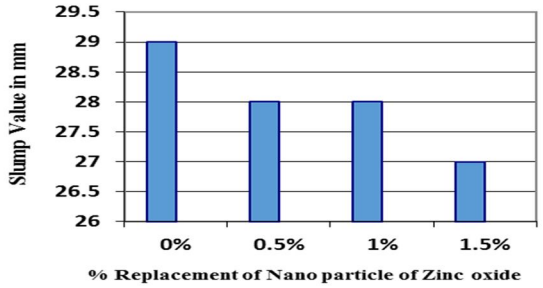
Percentage of zinc oxide	Weight of Cement (kg/m^3)	Weight of zinc oxide (kg/m^3)	Weight of Water (kg/m^3)	Weight of C.A. (kg/m^3)	Weight of F.A. (kg/m^3)	Admixture (kg)
0%	391.57	0	148.8	1285.36	718.41	3.91
0.50%	389.62	1.95	148.8	1285.36	718.41	3.89
1.00%	387.66	3.91	148.8	1285.36	718.41	3.87
1.50%	385.7	5.87	148.8	1285.36	718.41	3.85

A. Slump Cone Test

This experiment is executed to confirm the workability of newly casted concrete. This test independently executed on newly casted concrete and the Cement replacing with Nano particles of Zinc oxide to find the workability. The slump is very valuable in identifying variations in the consistency of a mix of given nominal proportions; it is a measure of consistency of the fresh concrete. This test is conducted immediately after the concrete has been made.

Table 6: Slump value of Concrete Mix

% Replacement	**Slump Value**
0%	29mm
0.5%	28mm
1%	28mm
1.5%	27mm



Graph 1: slump value of cement concrete

B. Compressive Strength Test

Concrete is weak in tension and strong in compression so the concrete should be strong to achieve improve compression stregth. In this investigation for each mix 3-samples were examined and the average strength is in comparison with nominal Mix of M 35. Compressive strength test obtained excessive amount of compressive load a material can endure under facture limit. The outcomes of compressive strength on the curing period 7_{th} day, 14_{th} day & 28_{th} day are shown in table 7.

Table 7: Compressive strength results at different curing stages

Percentage Replacement of Zinc oxide	Compressive Strength (N/mm^2)		
	7 Days	14 Days	28 Days
0%	27.90	38.55	42.22
0.5%	31.03	42.93	46.86
1%	33.73	45.36	50.24
1.5%	32.29	44.19	49.22

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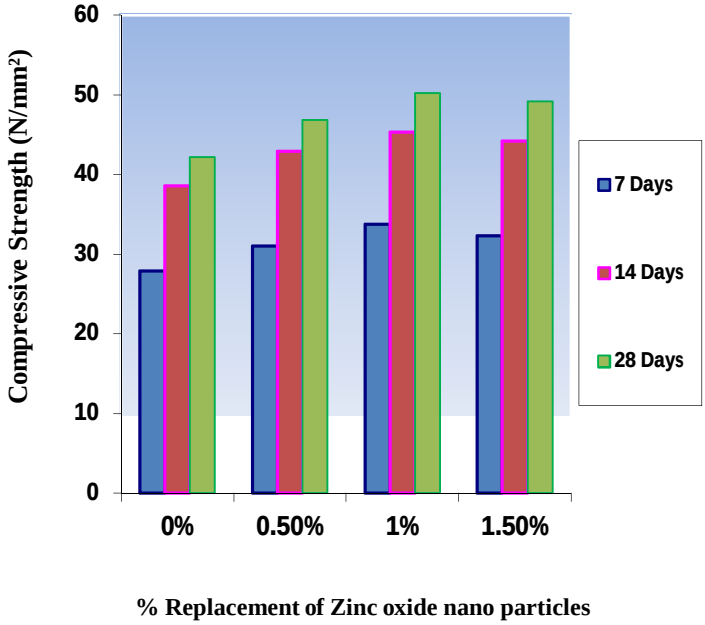

Graph 2: Compressive Strength at different Curing Stages

C. Durability

durability test of Concrete is most important for the suitable function of structure during its period. In this investigation curing of cubes after 28 days a salt cycles tests were performed by 10% concentrated sodium chloride solution. In this test cycles of soaking and drying of samples are done. When the weight loss of sample exceeds 2% the test is stopped.

Table 8: Durability with replacement of ZnO with Cement

Cycles	Dry Weight of concrete (kg)			
	Control	$NZ_{0.5}$	NZ_1	$NZ_{1.5}$
0	8.500	8.400	8.500	8.557
15	8.492	8.398	8.497	8.554
20	8.479	8.392	8.490	8.543
25	8.450	8.377	8.475	8.528
30	8.420	8.355	8.460	8.513
35	8.380	8.330	8.445	8.497
40	8.360	8.290	8.430	8.482
45	8.345	8.260	8.405	8.457
47	8.329	8.235	8.392	8.445
50	-	8.232	8.380	8.437
55	-	-	8.350	8.415
60	-	-	8.330	8.400
65	-	-	-	8.386

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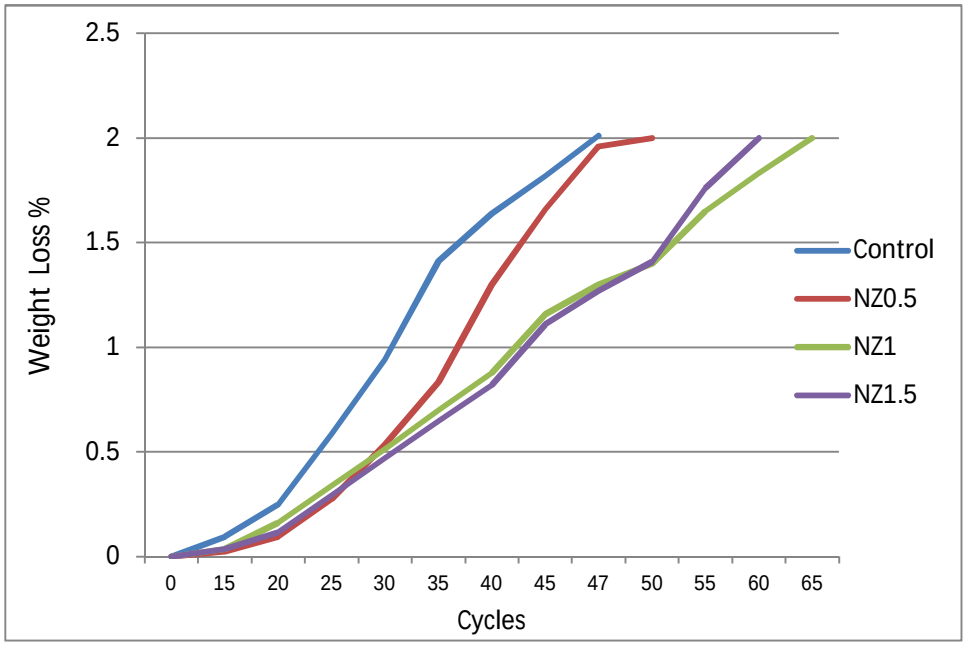

Graph 3: weight-loss curves for Concrete

IV. CONCLUSION

Based on the experimental investigation it is obtained 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.

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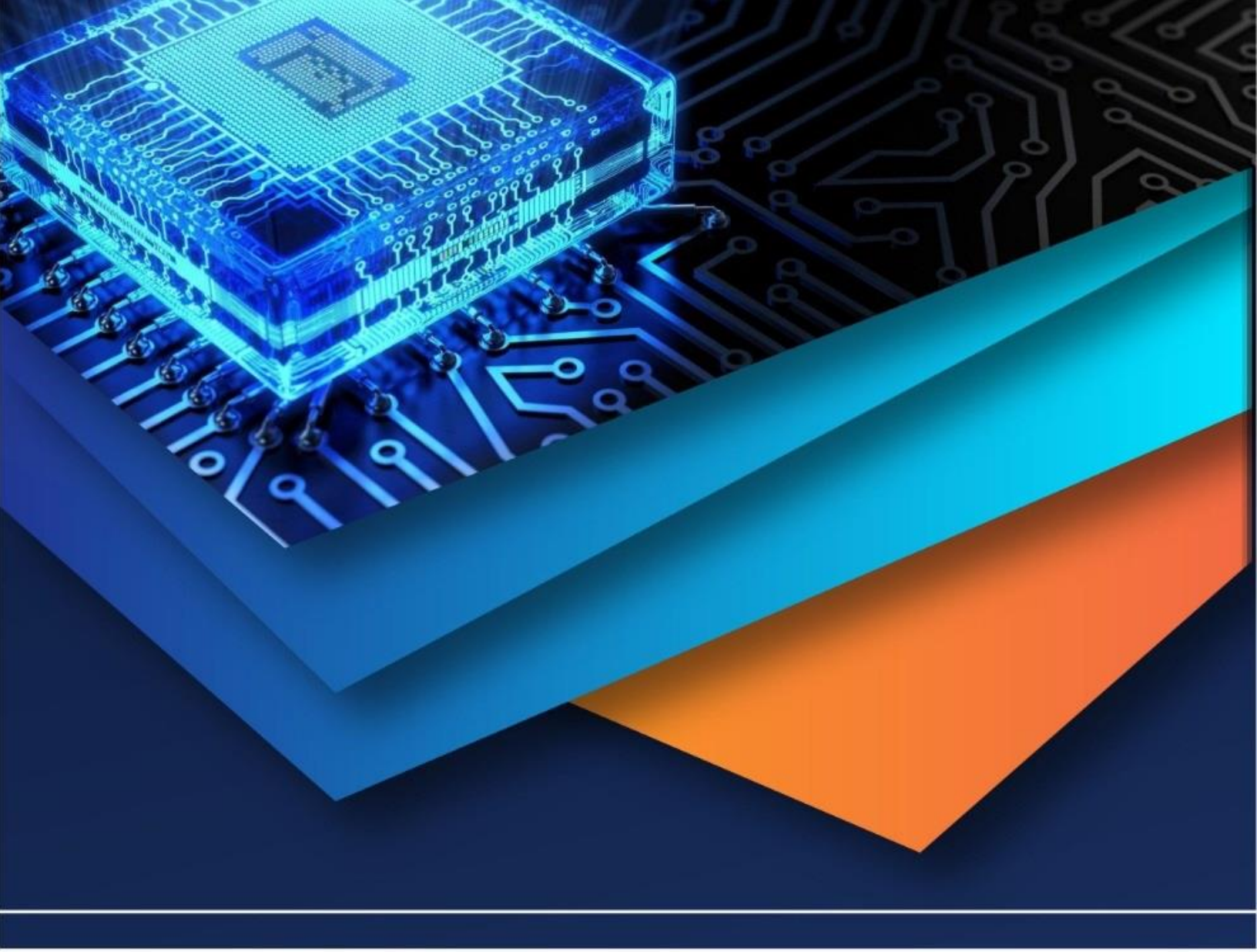

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