NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26

NANOPARTICLES: AN EXPERIMENTAL STUDY OF ZINC NANOPARTICLES TOXICITY

S.ThahiraBanu, P.Rajeshwaran, K. Suriyaprakash, A.Subalakshmi
Department of CivilEngineering, Sethu Institute of Technology, Pulloor,Kariapatti –626115, Virudhunagar District, Tamilnadu, India.

Abstract:
Nanoparticles are highly efficient additives for modification of cement products, even at small concentrations (<1%). The main modifications are reduction of set time (by 1h –2 h) and increase of strength (by 5–25%). One limitation has been the high cost of NPs relative to the other ingredients of concrete. The prime concern is related to the development of sustainable concrete with enhancement of performance in terms of strength and durability. Zinc oxide (ZnO) nanoparticles have unique optic, antimicrobial and photocatalytic activity. These ultra-fine nanoparticles have a filler effect and have been found to impact the hydration reaction in the cement matrix. This paper highlights the beneficiary role of zinc oxide nanoparticles in improving the performance of cement composites. Therefore, the objective of this study is to synthesize zinc oxide nanoparticles in the most practical ways by using the sol-gel method and characterize the nanoparticles. In the present study, the mechanical properties of mortars were investigated after the addition of different amounts of ZnO nanoparticles. The zinc oxide nanoparticles, with an average particle size of about 95 nm, were synthesized and their properties were studied with the help of a scanning electron microscope (SEM) and X-ray diffraction. The prepared nanoparticles were partially added to mortars at different concentrations (0.5, 1, 1.5, %), and the mechanical (flexural and split tensile) strength of the specimens measured after 7, 14, 28 and 56 days, respectively. Some specific objectives in our thesis works are i) To determine the Strength performance of cement composites highly influenced by nanomaterial type and content. ii) To examine the effect of ZnO nanoparticles on microstructure of cement matrix. iii) To inspect the effect of ZnO nanoparticles on durability performance of cement matrix.

Keywords: Zinc oxide, Nanoparticles, sustainable concrete, microparticles, flexural and split tensile strength, Synthesis

1. Introduction

A nanoparticle or ultrafine particle is usually defined as a particle of matter that is between 1 and 100 nanometres (nm) in diameter.[1][2] The term is sometimes used for larger particles, up to 500 nm,[citation needed] or fibers and tubes that are less than 100 nm in only two directions.[3] At the lowest range, metal particles smaller than 1 nm are usually called atom clusters instead. Nanoparticles are usually distinguished from microparticles (1-1000 µm), "fine particles" (sized between 100 and 2500 nm), and "coarse particles" (ranging from 2500 to 10,000 nm), because their smaller size drives very different physical or chemical properties, like colloidal properties and

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26

ultrafast optical effects[4] or electric properties.

Being much smaller than the wavelengths of visible light (400-700 nm), nanoparticles cannot be seen with ordinary optical microscopes, requiring the use of electron microscopes or microscopes with laser. For the same reason, dispersions of nanoparticles in transparent media can be transparent,[5] whereas suspensions of larger particles usually scatter some or all visible light incident on them. Nanoparticles also easily pass through common filters, such as common ceramic candles,[6] so that separation from liquids requires special nano filtration techniques. Nanoparticles occur in a great variety of shapes, which have been given many informal names such as nano spheresnanorods, nanochains, Nano stars, nanoflowers, Nano reefs, Nano whiskers, nanofibers, and Nano boxes.

The shapes of nanoparticles may be determined by the intrinsic crystal habit of the material, or by the influence of the environment around their creation, such as the inhibition of crystal growth on certain faces by coating additives, the shape of emulsion droplets and micelles in the precursor preparation, or the shape of pores in a surrounding solid matrix.[38] Some applications of nanoparticles may require specific shapes, as well as specific sizes or size ranges. There are unique challenges associated with the measurement of mechanical properties on the nanoscale, as conventional means such as the universal testing machine cannot be employed. As a result, new techniques such as nanoindentation have been developed that complement existing electron microscope and scanning probe methods.[65] Atomic force microscopy (AFM) can be used to perform nanoindentation to measure hardness, elastic modulus, and adhesion between nanoparticle and substrate.

Based on recent research works it is clear that the strength level, porosity, mix composition and type, water content, specimen geometry, nano size scale, nanoparticle type, nanoparticle content, the combination of nanoparticles and material age take a crucial role in the physical properties of cementitious materials modified with nanoparticles. It is recommended that different sizes of nanoparticles should be used in such materials as well as polypropylene fibres when subjected to high temperatures. The content of nanoparticles in such materials should be also lower for fire applications than for only ambient temperature purposes. Additionally, there is still an absence of knowledge and comprehension of the response of such materials under high temperatures, which highlights the urgent need for further research into this topic.

1.2 Motivation

Nanoparticles present possible dangers, both medically and environmentally. Most of these are due to the high surface to volume ratio, which can make the particles very reactive or catalytic. Recent study looking at the effects of ZnO nanoparticles on human immune cells has found varying levels of susceptibility to cytotoxicity.

1.3 Objectives

One of the main objectives of the environmental nanotechnology is safe design and sustainable development of nanomaterial with potential environmental benefits. Some specific objectives in our thesis works are

- To determine the Strength performance of cement composites highly influenced by nanomaterial type and content.
- To examine the effect of ZnO nanoparticles on microstructure of cement matrix.
- To inspect the effect of ZnO nanoparticles on durability performance of cement matrix.

1.4 Social Relevance Of The Project

Nanotechnologies may provide new solutions for the millions of people in developing countries who lack access to basic services, such as safe water, reliable energy, health care, and education.

- Zinc oxide nanoparticles are being widely used in the nanotechnology industry. Due to the release of particles from zinc oxide nanoparticles containing products, it is likely that nanoparticles will enter the soil compartment mainly through the application of sewage mud sludge obtained from waste water treatment applications.
- Antibacterial activity of zinc oxide nanoparticles (ZnO-NPs) has received significant interest worldwide particularly by the implementation of nanotechnology to synthesize particles in the nanometre region.
- Zinc oxide (ZnO) nanoparticles have unique optic and photocatalytic activity. These ultra-fine nanoparticles have a filler effect and have been found to impact the hydration reaction in the cement matrix. The introduction of ZnO nanoparticles has been found to impart photocatalytic properties in the cement structures.

2.Literature Study

Mohammad Reza Arefi 1,andSaeedRezaei-Zarchi 2” Synthesis of Zinc Oxide Nanoparticles and Their Effect on the Compressive Strength and Setting Time of Self-Compacted Concrete Paste as Cementitious Composites” International Journal of Molecular Sciences. 2012doi:10.3390/ijms13044340 proposed the mechanical properties of self-compacting concrete were investigated after the addition of different amounts of ZnO nanoparticles. The zinc oxide nanoparticles, with an average particle size of about 30 nm, were synthesized and their properties studied with the help of a scanning electron microscope (SEM) and X-ray diffraction. The prepared nanoparticles were partially added to self-compacting concrete at different concentrations (0.05, 0.1, 0.2, 0.5 and 1.0%), and the mechanical (flexural and split tensile) strength of the specimens measured after 7, 14, 21 and 28 days, respectively. The present results have shown that the ZnO nanoparticles were able to improve the flexural strength of self-compacting concrete. The increased ZnO content of more than 0.2% could increase the flexural strength, and the maximum flexural and split tensile strength was observed after the addition of 0.5% nanoparticles. Finally, ZnO nanoparticles could improve the pore structure of the self-compacted concrete and shift the distributed pores to harmless and less-harmful pores, while increasing mechanical strength.

Mir Firasath Ali1, Mohammed TalhaRashed 2, Mohammed Abdul Bari 3, Khaja Mohammed “Effect of Zinc Oxide Nanoparticle on Properties of Concrete” International Research Journal of Engineering and Technology (IRJET) Feb 2022 suggested that 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 nanoZnO 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 ZnOnano 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.

Mukesh Kumar a ,ManjeetBansal a , RishavGarg b "An overview of beneficiary aspects of zinc oxide nanoparticles on performance of cement composites " ScienceDirect . 12 July2020observed Nanotechnology provides an innovative approach at the interjection of science and technology especially in the concrete sector to solve the issues prevailing in the construction industry. The prime concern is related to the development of sustainable concrete with enhancement of performance in terms of strength and durability. On the parallel concern is related to decrease in cement use and production leading to reduced global carbon dioxide emissions. As per literature, various nanoparticles have been used in this context as a partial substituent for cement due to their small size, high surface area and pozzolanic action. This review highlights the beneficiary role of zinc oxide nanoparticles in improving the performance of cement composites. Study reveals that with optimized dosage of these nanoparticles, mortars and concrete with increased mechanical strength and antimicrobial properties can be prepared. It provides an innovative pathway in construction industry to build self-cleaning, durable and eco-friendly structures.

Gopalakrishnan, Ramasamy; Nithiyanantham, Subramanian "Effect of ZnO Nanoparticles on Cement Mortar for Enhancing the Physico-Chemical, Mechanical and Related Properties" ScienceDirect .12 July2020.DOI:https://doi.org/10.1166/asem.2020.2505studied Zincoxide nanoparticles have been incorporated into the cementitious materials for enhancing their physico-chemical and mechanical properties. The decrease in particle size will leads the increase in surface to volume ratio as compared to conventional micro-particles. In this investigation to evaluate physical, chemical and mechanical properties of Ordinary Portland Cement (OPC) containing zinc oxide nanoparticles. Zinc oxide nanoparticles used with replacement of various properties such as 0%, 1%, 2%, 3%, 4% and 5% by weight with ordinary Portland cement. The ordinary Portland cement mortar, nanozincoxide cement mortars prepared with the water-binder ratio (w/b ratio) as 0.4 and cement-sand ratio as 1:3 by weight. The prepared mortars are analyzed through compressive strength, setting time, flexural strength, porosity, water absorption, sulphate attack, electrical resistivity and with SEM analysis. The setting time of zinc oxide nano particle significantly decreased and enhanced the compressive strength of Portland cement mortar. The flexural strength outcomes showed that the cement mortars with zinc oxide nanoparticle were higher rather than Portland cement mortar. Microstructure of mortar contained zinc oxide nano particles illustrate that the nano zinc oxide particles filled the pores significantly and so large size of calcium hydroxide crystals reduced afterwards more hydration products formed.

D. Nivethitha ,S. Dharmar "Effect of Zinc Oxide Nanoparticle on Strength of Cement Mortar" IJSTE - International Journal of Science Technology & Engineering . November 2016. used Nanotechnology is one of the extreme active research area and development activity that has been growing explosively worldwide in the past few years. Nanoparticle belongs to be promising materials in the field of Civil Engineering. The main aim of this study is to constitute a blended mortar with high mechanical properties. The influence of nano-particle on the mechanical properties such as compressive strength and split tensile strength of mortar were experimentally studied. The nano-particle used in this study was nano-Zinc oxide (NZno) with the average particle size of 60nm. The blended cement used in this study consists of ordinary Portland cement (OPC) and nano-zinc oxide particle. The cement was partially substituted by NZno of 0, 1, 3 and 5% by weight of cement. The blended mortar was prepared using cement-sand ratio of 1:2 by weight with constant water-binder ratio. The compressive strength and split tensile strength of mortar at 7 and 28 days were studied. The results show that the mechanical strength of sample comprising 3% and 5% ZnO nanoparticles are desired than traditional mortar. As a result, it is possible to add nano-ZnO particles to improve the mechanical properties of cement mortar.

J.N. Hasnidawani 1,a*, H.N. Azlina 1,b, H. Norita1,c, N.N. Bonnia2,d, S.Ratim2,e and E.S. Ali Synthesis of ZnO Nanostructures Using Sol-Gel Method 5th International Conference on Recent Advances in Materials, Minerals and Environment(RAMM) & 2nd International Postgraduate Conference on Materials, Mineral and Polymer(MAMIP), 4-6 August 2015

Zinc oxide plays an important role in current industry due to its special characteristics such as anti-corrosion, anti-bacteria, has low electrons conductivity and excellent heat resistance. Therefore, the objective of this study is to synthesize zinc oxide nanostructures with the most practical ways by using sol-gel method and characterize the nanostructures. Sol-gel method is the simplest method and has the ability to control the particle size and morphology through systematic monitoring of reaction parameters. ZnO nanoparticles were synthesized via sol gel method using Zinc acetate dehydrate (Zn(CH3COO)2.2H2O) as a precursor and ethanol(CH2COOH) was used as solvent, Sodium hydroxide (NaOH) and distilled water were used as medium. ZnO nanoparticles were characterized by using XRD, EDX, FESEM, and nano-particles analyser. Result of EDX characterization shows that the ZnO nanoparticles has good purity with (Zinc content of- 55.38% and; Oxygen content of- 44.62%). XRD result spectrum displays mainly oxygen and zinc peaks, which indicate the crystallinity in nature as exhibited. FESEM micrographs shows that synthesized ZnO have a rod-like structure. The obtained ZnO nanoparticles are homogenous and consistent in size which corresponds to the XRD result that exhibit good crystallinity. ZnO nanoparticles were successfully synthesized by sol-gel method in nanosize range within 81.28nm to 84.98nm.

2. Problem Identification

Concrete is a basic and most widely used construction material due to its ease of casting, strength and durability. It also needs up gradation due to new advancement in technologies like Nanotechnology, fibre reinforced concrete etc. From the literature survey it is observed that, some of the problems are identified in using cement in conventional concrete they are as follows:

- In recent years, many researchers also worked for enhancement of properties of concrete by adding different additive Nano materials and found some positive result. But it is still not widely used due to its cost of production, environmental issues and health hazard etc.
- A large number of different types of structure using concrete are constructed every year in the world. Due to change in recent trends in construction industry, ordinary concrete cannot give a needful result.
- For constructing heavy structure like bridges, multi-storeyed building, sea shore structures and many more structure, there is a very high demand of advance concrete, which can fulfil the need of higher strength and ease of construction. The demand of these type of concrete for a better infrastructure are increasing rapidly due to fast growth of urbanization.

4.Problem Solution

Various Nano materials, which are being used in construction industry or on which various researches are going on, are Nano Silica, Nano Titania, Carbon Nanotubes, Carbon Nano fibre, Nano Alumina, Nano $ZrCO_2$, Nano $CaCO_3$, Nano clay, Nano Fe_2O_3, Nano CuO etc.

- The market demand for the ZnO Nano powders is increasing and widely used in industries due to their ultraviolet filtering, catalytic, anti-corrosion and anti-bacterial properties.
- Recently, they have mainly been used in sunscreens as an ultraviolet-resistant additive. Other applications of zinc oxide Nano powder include electrophotography, photo printing, capacitors, protective coatings, anti-microbial, and conductive thin-films in LCDs, solar cells, and blue laser diodes.
- At nano level the gravity forces become less influential, electrostatic forces become more important and quantum effect rises as particle becomes nano sized, the proportion of atoms on the surfaces increases relative to those inside which causes nano effects.
- It is believed that finer particles i.e particle of micro size or nano size have large surface area per unit volume which is important for cement and concrete. Large surface area of binder results in high early strength and also helps in increasing ultimate strength due to faster and more effective hydration reaction.

5.Materials and Experiment

- Zinc oxide nanoparticle appears to be white powder and insoluble in water. Zinc oxide nanoparticle has an energy band of 3.37 eV and a bonding energy of 60 meV, which provides its excellent chemical, electrical, and thermal stabilities. Zinc oxide nanoparticle also has optical, electrical, and photocatalytic properties.The studies were carried out on four major mixes, one ordinary control mix to compare other mix strength, then by adding zinc oxide nanoparticles by various concentrations like 0.5%, 1% and 1.5%,.
- All mixes were confirming to IS 4031 (Part 6) – 1988 as 200g of cement, 800g of sand and found water consistency as mentioned. Also, specimens with ZnoNps at 1% by volume, found to be optimum for microstructure of cement matrix.

Destructive testing like Compression testing was conducted on mortar of size 70.6 mm × 70.6 mm × 70.6 mm, as per IS considerations. All specimens were manually mixed with distilled water, placed into well-greased moulds and compacted on vibrating table till air bubbles disappear. While adding zinc oxide nanoparticles to the matrix, ultra sonication was carried out for even dispersion to the mix. Destructive testing like Compression testing was conducted on mortar of size 70.6 mm × 70.6 mm × 70.6 mm, as per IS considerations.

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26

Mix proportions

Particulars	CEMENT	SAND	WATER	NP ZINC
Unit	*gms*	*gms*	*ml*	*gms*
Control Mix	200	800	88	-
ZnP 0.5	200	800	88	1
ZnP 1	200	800	88	2
ZnP 1.5	200	800	88	3

6.Design Consideration For Public Health,Safety And Environment

IS:4031 (Part-6): 1988 Methods of Physical Tests For Hydraulic Cement

This standard IS 4031 (Part 6) covers the procedure of finding out compressive strength of cement: The strength of cement is determined by compressive strength tests, on 70.6 mm mortar cubes, made with specified cement, sand & water mixed & compacted manually with a compacting bar as well as with vibrating machine.

IS:383-1970–Specification For Coarse And Fine Aggregates From Natural Sources For Concrete.

The grading of fine aggregates, when determined as described in IS: 2386 (Part I)-1963 shall be within the limits given in Table 4 and shall be described as fine aggregates, Grading Zones I, II, III and IV: Where* the grading falls outside the limits of any particular grading zone of sieves other than 600-micron IS Sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600-micron IS Sieve or to percentage passing any other sieve size on the coarse limit of Grading Zone I or the finer limit of Grading Zone IV.

IS:1489(Part1):1991 Portland Pozzolana Cement Specipication (Part 1 Fly Ash Based)

The average compressive strength of not less than three mortar cubes (area of face 50 cm*) composed of one part of cement, three parts of standard sand by mass, and P/4 + 3.0 percent (of combined mass of cement and sand) water, and prepared, stored and tested in the manner described in IS 4031 (Part 6): 1988 shall be as follows:

a) At 72 f 1 h I6 MPa, Min

b) At 168 =t 2 h 22 MPa, Min

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26

c) At 672 rt 4 h 33 MPa, Min

IS:4031(Part-6): 1988 Methods Of Physical Tests For Hydraulic Cement

The material for each cube shall be mixed separately/and the quantity of cement, standard sand and water shall be as follows: Cement 200g Standard 600 g Sand Water (+ 3'0) percent of combined mass of cement and sand, whether P is the percentage of water required to produce a paste of standard consistency determined as described in IS: 4031 (Part 4) - 1988*. Place on a nonporous plate, a mixture of cement and standard sand, mix it dry with a trowel for one minute and then with water until' the mixture is of uniform colour. The quantity of water to be used shall be as specified. The time of mixing shall in any event be not less than 3 min and should the time taken to obtain a uniform colour exceed 4 min, the mixture shall be rejected and the operation repeated with a fresh quantity of cement, sand and water.

7.Methods and Modern Tools Used

Universal Testing Machine (compression testing, split tensile testing)

A universal testing machine also known as universal tester, is used to test the tensile strength and compressive strength of materials. An earlier name for a tensile testing machine is a tensiometer. The universal part of the name reflects that it can be perform many standard tensile and compression test on materials, components and structures.

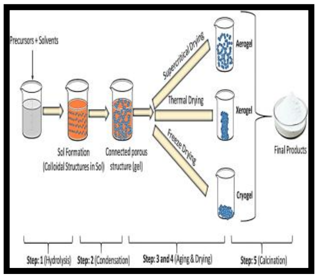
UTM provides the value of load application and the respective displacements. From the observed value, the load deflection graph is obtained. With the load value in the y-axis and the displacement in the x-axis. The displacement is actually the movement of the crossheads during the load application. From the load deflection curve , the stress-strain analysis, modulus of elasticity, yield strength of the specimen tested can be determined.

7.1 Synthesis of Nanoparticles

Zinc Oxide nanostructure was synthesized by using sol-gel method. In order to prepare a sol, 2 g of Zinc Acetate and 8 g of Sodium Hydroxide were weighted using a weighting balance. Then, 10 ml and 15 ml of distilled water were measured by a measuring cylinder. After that, 2 g of zinc acetate was dissolved with a 15 ml of distilled water and 8 g of sodium hydroxide was dissolved in a 10 ml of distilled water. The solutions were stirred with a constant stirring for about five minutes each. After well mixed, sodium hydroxide solution was poured to the solution containing zinc acetate with a constant stirring by magnetic stirrer for about five minutes. Then, a burette was filled with 100 ml of ethanol and titrate drop wise to the solution containing both sodium hydroxide solution and zinc acetate. After the reaction, white precipitate was formed. The precipitated ZnO nanoparticles were cleaned with deionized water and ethanol, and then dried in air at about 80 °C. Imaging of the synthesized ZnO nanoparticles was undertaken by a scanning electron microscope.

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26



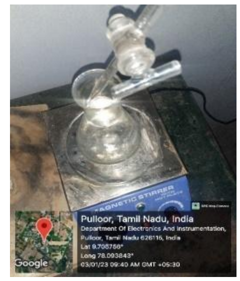
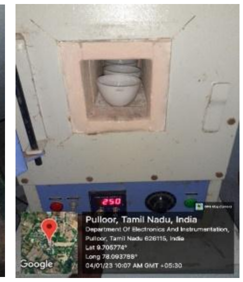



Fig.1. Synthesis ProcessFig 2.10 min mixingFig3:4gZinc+15 ml of water Fig 4. Titration processFig 5. Thermal drying

(magnetic stirrer)

Based on the experimental work that has been done, there are series of chemical reaction that takes place. The complete hydrolysis of zinc acetate with the aid of NaOH in an ethanolic solution should result in the formation of ZnO colloid. The final product was obtained as a result of the equilibrium between the hydrolysis and condensation reaction. Due to the heating, Zinc Acetate within the solution undergoes hydrolysis forming acetate ions and zinc ions.

The abundance of electrons in the oxygen atoms makes the hydroxyl groups (-OH) of alcohol molecules bond with the zinc ions5. The overall chemical reaction to form ZnOnano-powder when sodium hydroxide was used as solvent stated as follow:

$(Zn(CH_3COO)_2.2H_2O) + 2NaOH\ ZnO + 2NaCH_3COO + H_2O$

Zinc hydroxide acetate is an intermediate product of the hydrolysis reaction, formed in the presence of H_2O and OH ions.It can be easily transformed into ZnO at higher temperature and with prolonged refluxing. Sodium acetate is water soluble and could therefore be removed from the end product. High purity ZnOnano-powder could therefore be obtained successfully by sol gel technique.

7.2 Field Emission Scanning Electron Microscope (FE-SEM)

There are varieties of ZnO nanostructures that had been discovered, which are in a form of nanorods, nanotubes, nanobelts, Nano springs, Nano spirals, nanoring's and many more (Bahadur et al. 2008). In addition, rod like structure is the best nanostructure compared to others due to their one-dimensional nanostructures (example: nanorods, nanowires, and nanotubes) that can facilitate more efficient carrier transport because of decreased grain boundaries, surface defects, disorders, and discontinuous interfaces (Morkoç&Ozgur, 2009; and Moezzi, et al., 2012).

Morphology study has found out synthesized ZnO are in form of rod like structure as the result of zinc acetate were used as precursor. It was supported by other findings, which Bahadur et.al (2007) claimed that the

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26

morphology of ZnOnano-powder using zinc acetate is smoother than in zinc nitrate. Moreover, precursor concentration plays a great role on morphological features of nanorod. According to Pourrahimi et al. (2014), ZnO can be form in different structures due to the type of precursors that has been used, such; Zinc acetate nano rod like structure, zinc chloride and sulphate-nano-prism structure and zinc nitrate-prism flower shape structure. Kashif et al. 2012 claimed that increase in the concentration of precursor would increase the growth and density of ZnOnanorod, when length of nanorod is reduced. In addition, rod like structure is the best nanostructure compared to others due to their one-dimensional nanostructures (example: nanorods, nanowires, and nanotubes).

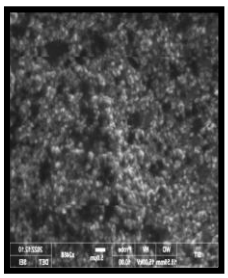
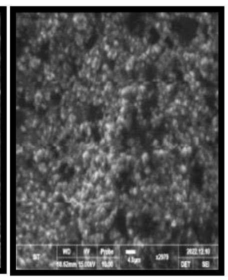
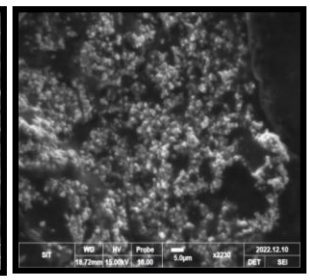
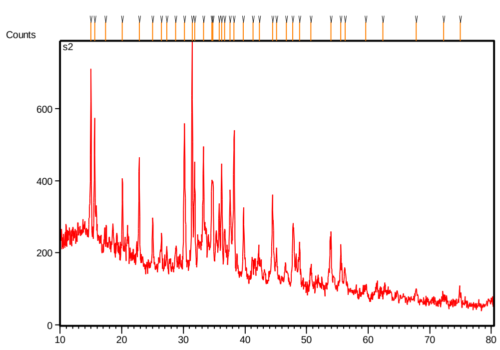




Fig 6.Sem Result (Sample 1)Fig.7 Sem Result (Sample 2)Fig 8Sem Result (Sample 3)

X-Ray Diffractometer (XRD)-XRD analysis determined the phase's presence in Nano powder. XRD result as shows in Fig. 6 are the resulting pattern of ZnOnano-powder in various profiles of peak and diffraction angle 2θ, which represent the diffraction of ZnOnano-powder using Zinc Acetate as precursor. The XRD pattern of the powder was recorded in the fraction angle range 10° to 80°. The figure shows sharp peaks of ZnO, which indicate the crystallinity in nature.

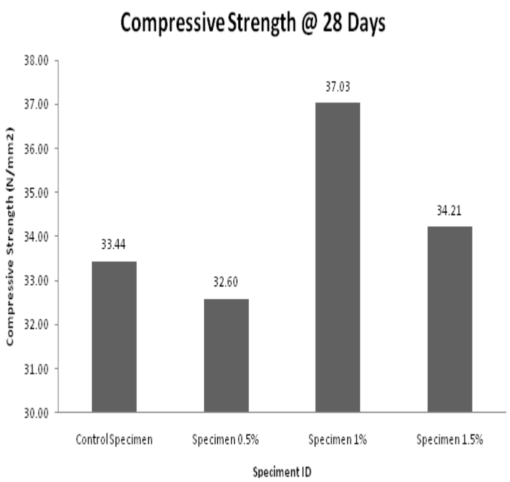


Pos. [°2Th]	Height [cts]	FWHMLeft [°2Th]	d-spacing [Å]	Rel. Int. [%]
10.2398	284.21	0.4723	8.63893	2.63
13.6606	300.01	1.2595	6.48234	2.77
17.6561	4336.39	0.1181	5.02339	40.09
17.8549	3829.30	0.1181	4.96789	35.40
20.7105	204.08	0.9446	4.28892	1.89
26.5860	7834.13	0.1181	3.35291	72.42
26.8567	4878.93	0.1574	3.31972	45.10
30.1891	453.34	0.1181	2.96044	4.19
34.2832	362.75	0.1181	2.61570	3.35
35.6779	10817.39	0.1181	2.51659	100.00
36.1040	3550.13	0.2362	2.48785	32.82
38.0824	285.33	0.1574	2.36304	2.64
39.8106	146.61	0.6298	2.26436	1.36
41.5930	222.43	0.1574	2.17135	2.06
44.4698	160.83	0.2362	2.03733	1.49
44.9851	521.60	0.1574	2.01519	4.82
45.4459	162.46	0.1574	1.99582	1.50
48.4009	94.80	0.2362	1.88065	0.88
50.4645	69.90	0.4723	1.80849	0.65
53.5458	86.67	0.2362	1.71146	0.80
54.7619	60.42	0.3149	1.67630	0.56
64.6883	17.57	0.9446	1.44099	0.16
73.0792	9.33	1.8893	1.29487	0.09

Fig.4.13: XRD Result

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26



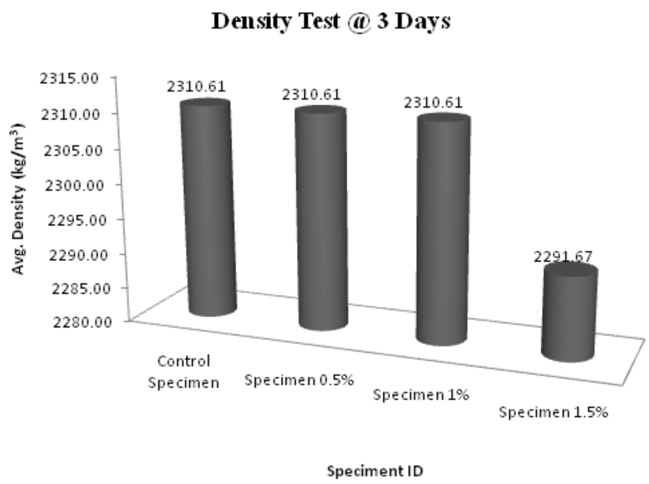
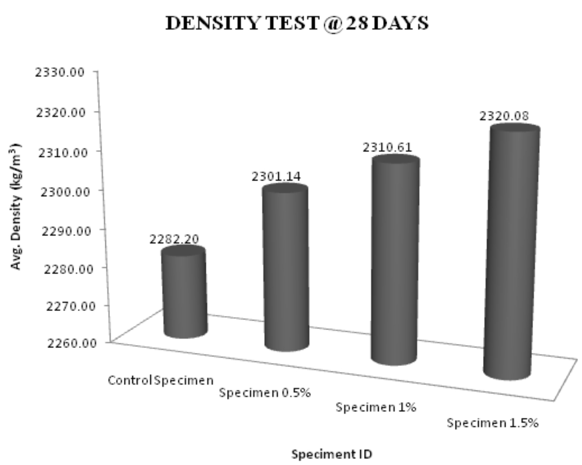


Fig.5 Compresive Strength at 28 Days

Fig.6 Density Testat 3 Days



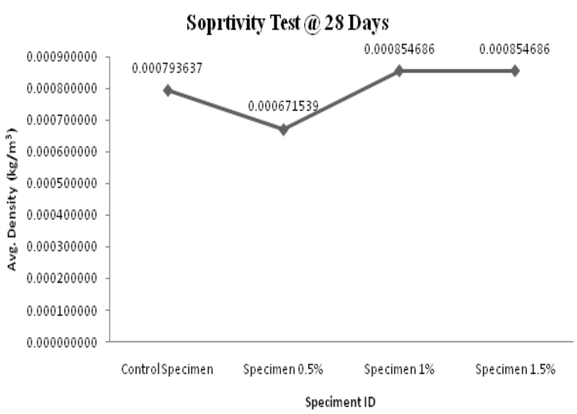


Fig 7 Density Test at 28 Days

Fig.8 Sorptivity Testat 28 Days

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN
Volume 13, Issue 2 | April 2023 Pages 13-26

8.Conclusion

The effect of zinc nanoparticles on mortar can vary depending on several factors, including the concentration of nanoparticles, mix design, curing conditions, and specific characteristics of the mortar. However, based on research and studies, the following conclusions can be drawn regarding the effect of zinc nanoparticles on mortar:

Enhanced Mechanical Properties: Zinc nanoparticles have shown the potential to improve the mechanical properties of mortar. Studies have reported an increase in compressive strength, and toughness of mortar when zinc nanoparticles are incorporated. The nanoparticles contribute to improved interfacial bonding and fill the voids in the mortar matrix, resulting in enhanced strength and durability.

Reduced Water Absorption: Incorporating zinc nanoparticles in mortar have been found to reduce water absorption. The nanoparticles help in filling the capillary pores, reducing the interconnected pore network, and enhancing the resistance to water penetration. This can lead to improved moisture resistance and durability of the mortar.Enhanced Antibacterial Properties: Zinc nanoparticles possess antibacterial properties and have shown the ability to inhibit the growth of bacteria in mortar. This can be beneficial in applications where microbial growth, such as in damp environments or infrastructure exposed to moisture, needs to be controlled.Improved Chemical Resistance: Zinc nanoparticles have been observed to enhance the chemical resistance of mortar. They can provide a protective barrier against the ingress of aggressive chemicals, such as chloride ions or sulfates, thus reducing the deterioration of the mortar due to chemical attacks.Potential Environmental Benefits: Zinc nanoparticles are considered environmentally friendly and have low toxicity. Using these nanoparticles in mortar can contribute to sustainable construction practices, especially in applications where environmental concerns are important.

It's important to note that the effectiveness and specific outcomes of incorporating zinc nanoparticles into mortar may vary depending on the experimental conditions and specific application requirements. Further research and testing are needed to optimize the concentration, dispersion methods, and long-term performance of zinc nanoparticle-modified mortar for different applications.Overall, the incorporation of zinc nanoparticles in mortar shows promise for enhancing its mechanical properties, reducing water absorption, providing antibacterial properties, and improving chemical resistance. However, it is recommended to consult specific research studies and seek expert advice for detailed insights and recommendations when considering the use of zinc nanoparticles in mortar applications.From the experimental data, the following conclusions can be drawn:The zinc oxide nanostructure was successfully synthesized by using sol-gel method. The results showed that the ZnO rod like structure was successfully synthesized by sol gel method in nanosize range about 571.98nm. The synthesized ZnO nano-powder obtained exhibit good crystallinity.Development of sustainable concrete with enhanced strength and durability is highly desirable. The use of nps as a partial substituent has been regarded as an effective and eco-friendly approach to prepare building structures.Mortar mixes containing ZnP 1% shows increase in compressive strength @ 7 & 28 Days.Higher strength mortar typically exhibits lower water absorptionbecause it has a denser and more compact structure. Hence Mortar mixes containing ZnP 1% shows lower water absorption.The relationship between density and strength in materials, including mortar, can vary depending on several factors such

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
ISSN: 2231-2099 | NJICE - WWW.NJICE.IN

Volume 13, Issue 2 | April 2023 Pages 13-26

as the composition, porosity, and structural characteristics of the material. Here are some general observations regarding the relationship between density and strength, Mortar mixes containing ZnP 1% shows normal density compared to conventional mixes.Sorptivity is considered a durability property in the context of construction materials. It provides valuable information about the ability of a material to resist moisture ingress and the potential for damage due to water absorption.High sorptivity indicates that a material has a greater propensity to absorb water and transport it through capillary action. Typically, the sorptivity coefficient for mortar ranges from 0.001 to 0.010 m/s^0.5. This range is commonly reported for mortar with a water-cement ratio in the range of 0.4 to 0.5. However, it's important to note that the sorptivity coefficient can vary based on the specific mix design and other factors. Our Experimental Results shows that sorptivity values of all mixes are in the range.

References

1.Behfarnia.K, A. Keivan,The Effects of Tio2 And Zno Nanoparticles on Physical Mechanical Properties of Normal Concrete , vol 14(4) · (2011) pp 517 -531

2.Behfarnia T.K., A. Keivan and , “The Effects Of Tio2 And Zno Nanoparticles On Physical and Mechanical Properties Of Normal Concrete.” Asian Journal Of Civil Engineering (Bhrc) Vol. 14, No 4 ,2013,PP 517-531 .

3.Mohammad Reza Arefi. Saeed Rezaei-Zarchi. Synthesis ofZinc Oxide Nanoparticles and Their Effect on The Compressive Strength and Setting Time of Self-Compacted Concrete Paste as Cementitious Composites,vol 13(4): ,(2012),PP 4340–4350

4.M.K. Mohsen, T. H. Sepehri, M. Sepehri, “Influence of Nano-Silica Particles on Mechanical Properties and Permeability of Concrete”, 2010, Second internationalTTConference on sustainable construction materials and technologies.

5.S. Riahi, A. Nazari, “Physical, mechanical and thermal properties of concrete in different curing media containing ZnO2 nanoparticles”, 2011, Energy and Buildings 43, 1977–1984.

6.Ghafari, S.A. Ghahari, Y. Feng, F. Severgnini, N. Lu,” Effect of Zinc oxide and Al-Zinc oxide nanoparticles on the rheological properties of cement paste”, 2016, Composites Part B 105, pp 160-166.E.

7.D. Nivethitha, S. Dharmar, “Effect of Zinc Oxide Nanoparticle on Strength of Cement Mortar”, 2016, International Journal of Science Technology & Engineering, Volume 3, Issue 05.

8. Lee SH, Tang CH, Lin WY, Chen KH, Liang HJ, Cheng TJ, et al. LC-MS-based lipidomics to examine acute rat pulmonary responses after nano- and fine-sized ZnO particle inhalation exposure. *Nanotoxicology*. (2018) 12:439–52. doi: 10.1080/17435390.2018.1458918.

9. Chien CC, Yan YH, Juan HT, Cheng TJ, Liao JB, Lee HP, et al. Sustained renal inflammation following 2 weeks of inhalation of occupationally relevant levels of zinc oxide nanoparticles in Sprague Dawley rats. *J Toxicol Pathol*. (2017) 30:307–14. doi: 10.1293/tox.2017-0025.

10.Khosravi-Katuli K, Lofrano G, Pak Nezhad H, Giorgio A, Guida M, Aliberti F, et al. Effects of ZnO nanoparticles in the Caspian roach (*Rutilus rutilus* caspicus). *Sci Total Environ*. (2018) 626:30–41.doi: 10.1016/j.scitotenv.2018.01.085.

Volume 13, Issue 2 | **April 2023 Pages 13-26**

11.Poynton HC, Chen C, Alexander SL, Majior KM, Blalock BJ, Unrine JM. Enhanced toxicity of environmentally transformed ZnO nanoparticles relative to Zn ions in the epibenthic amphipod Hyalella Azteca. *Environ Sci Nano*. (2019) 6:325–40. doi: 10.1039/C8EN00755A.

12. Buccolieri A, Buccolieri G, Cardellicchio N, Dell'Atti A, Di Leo A, Maci A. Heavy metals in marine sediments of Taranto Gulf (Ionian Sea, Southern Italy). *Mar Chem*. (2006) 99:227–35. doi: 10.1016/j.marchem.2005.09.009.

13**.** Dekkers S, Oomen AG, Bleeker EA, Vandebriel RJ, Micheletti C, Cabellos J, et al. Towards a nanospecific approach for risk assessment. Regul Toxicol Pharmacol. (2016) 80:46–59. doi: 10.1016/j.yrtph.2016.05.037.

14.Landvik NE, Skaug V, Mohr B, Verbeek J, Zienolddiny S. Criteria for grouping of manufactured nanomaterials to facilitate hazard and risk assessment, a systematic review of expert opinions. Regul Toxicol Pharmacol. (2018) 95:270–9. doi: 10.1016/j.yrtph.2018.03.027.

15.Rycroft T, Larkin S, Ganin A, Thomas T, Matheson J, van Grack T, et al. A framework and pilot tool for the risk-based prioritization and grouping of nano-enabled consumer products. Environ Sci Nano. (2018) 6:356–65. doi: 10.1039/C8EN00848E.

16.Kisin ER, Murray AR, Keane MJ, Shi XC, Schwegler-Berry D, Gorelik O, et al. Single-walled carbon nanotubes: geno- and cytotoxic effects in lung fibroblast V79 cells. J Toxicol Environ Health A. (2007) 70:2071–9. doi: 10.1080/15287390701601251