iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VII **Month of publication:** July 2017

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VII, July 2017- Available at www.ijraset.com

Effect of Zinc Oxide Nanoparticle on Compressive Strength and Durability of Cement Mortar

Akhilesh Pratap Singh[1], Archana Tiwari[2]
[1]*P.G Student, Department Of Civil Engineering, M.I.T.S., Gwalior (India)*
[2]*Professor, Department Of Civil Engineering, M.I.T.S., Gwalior (India)*

Abstract: ***Nanotechnology is one of the latest investigation fields that has become popular worldwide in the past few years. These days, there is a swiftly rising concern in using nanoparticles in cement mortar to improve the mechanical and durability properties. The large surface area of nanoparticles leads to more chemical relations at the interface, which results in enhanced properties and functions. In this study, the compressive and durability property of cement mortar having nanoparticles of zinc oxide with the particle size of 50-60 nm is investigated. The major intention of this investigation is to get ready a blended mortar with enhanced mechanical properties. The results of Nano particle on the mechanical behaviour such as compressive strength and durability of mortar were experimentally investigated. The blended cement used in this study consists of Portland Pozzolana cement (PPC) and nano zinc oxide particles. The cement was moderately substituted by NZnO of 0, 0.5, 1, and 1.5 % by weight of cement. The mortar was prepared using cement – sand ratio of 1:2 and 1:3 by weight with water – binder ratio of 0.35. The compressive strength of cement mortar was obtained at 7, 14 and 28 days and conduct durability test of cement mortar by used 10 % NaCl solution upto exceed the 2% weight loss of mortar.***

Keywords: Cement mortar, ZnO nanoparticle, compressive and durable property

I. INTRODUCTION

Concrete is the spine of the construction industry & widely used construction material consisting of cementing material, fine aggregate, coarse aggregate and required quantity of water. The cement is the main ingredient of concrete which act as a binder. Cement is the necessary material to form the concrete. Production of cement causes pollution. Efforts are made to produce high strength concrete without increasing cement by incorporating Nano materials such as Nano zinc oxide, Nano titanium dioxide, Nano calcium carbonate and Nano silica etc so that extra cement is not required for the production of concrete of higher strength. This will lead to the efficient use of cement and will maintain the sustainability of construction as well.Zinc oxide (ZnO) is a white solid inorganic substance that is thermally stable, nontoxic and is compatible with human skin making it a suitable additive for textiles and surfaces that come in contact with human body according to the Barnali Ashe [3]. Nano particles perform as heterogeneous nuclei for cement pastes, additional accelerating cement hydration, as a result of their high reactivity, as a nano-reinforcement, and as a nano-filler, making the microstructure denser, and thereby leading to a reduced porosity. An effort has been made to show that with ZnO nano particles, it is probable to achieve blended mortar with high mechanical and durability functions. Several investigations have shown that NZnO improves the mechanical properties and reduces the porosity of cement mortar and concrete. It improves the durability and strength of construction components,safety of the buildings, energy efficiency.

Several investigators have studied the mechanical and durability property of cement concrete containing nanoparticles. D. Nivethithha and dharmar *et.al* [1], have examined the compressive strength of cement mortar containig nano zinc oxide. From the experimental results compressive and split tensile strength was increased upto 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 ($CaCO_3$) nanoparticles and improve the mechanical and durable properties of concrete and mortar. Result show that at 1% nano-CaCO3 exhibited highest compressive strength up to 18% at 28 days in cement mortar. SupitAli Nazari et al [3], investigated have an impact on of Fe2O3 nanoparticle on the compressive electricity combined concrete, result display that compressive energy changed into elevated upto 15.48% at 1% Fe2O3. Rahmat Madandoust et.Al [4], have studied the have an effect on of nanoparticles at the residences of self-compacting mortar containing nano-SiO2 increased the compressive electricity up to fifteen.05% at 4% nano SiO2, and nano Fe2O3 accelerated the compressive electricity up to eleven.Sixty five% at 2% nano Fe2O3 and nano-CuO extended the compressive electricity as much as sixteen.39% at 3% nano CuO. Meral Oltulu et.Al [5], Have investigated for my part and coupled the impact of adding nanoparticles of nano-SiO2, nano-Al2O3 and nano-Fe2O3 to cement mortars containing silica fume accelerated the compressive power upto 27%. Ehsan Mohseni et.Al [6], have worked on Single and blended effects of nano-SiO2, nano-Al2O3 and nano-TiO2 at the mechanical, rheological and sturdiness residences of self-compacting mortar containing fly ash, result show that increasing the

©IJRASET (UGC Approved Journal): All Rights are Reserved

compressive strength upto 11.11% at 3% of nano-SiO_2 and 18.91% at 1% of nano-Al_2O_3 and 16.21% At 5% of nano-TiO2 and water absorption become accelerated at 5% of nano-SiO2 and and at 5% of nano-Al2O3 and water absorption was decreased at 5% of nano-TiO2. D nivethithha and dharmar *et.al* [7], Investigated have an effect on of ZnO nanoparticle at the compressive energy and sturdiness of cement mortar, end result show that compressive power become extended 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

II. MATERIAL USED AND PROPERTIES

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

A. *Properties of Material*

1) *Cement:* Portland Pozzolana cement (ppc) is used. Various test were conducted on cement such as consistency test, initial setting time, final setting time, specific gravity and fineness modulus. That properties shown in table-1.

Table 1: Properties of cement

S.No.	Properties	Results
1.	consistency	32%
2.	Initial setting time	120 min
3.	Final setting time	160 min
4.	Specific gravity	3.01
5.	Fineness modulus	3.66%

2) *River Sand :* particle size of aggregate between 4.75 mm to 150 micron are called as fine aggregate. River sand is used of zone-II confirming from the IS: 383-1970. That properties shown in table-2.

Table 2: Properties of fine aggregate

S.No.	Properties	Result
1.	Fineness modulus	3.37
2.	Specific gravity	2.48
3.	Water absorption	0.59%

3) *Nanoparticle Zinc Oxide:* NZnO with average particle size of 50-60 nm were used in this study. Standard size of nanoparticle should be between 1nm – 100 nm. Properties of NZnO is shown in table-3

Table 3: 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

4) *Fairflo SP-40 :-* Fairflo super placticizer water reducing mixture is used in this study. Properties of plasticizer are colour; Dark Brown, Type; Liquid, specific gravity 1.21.

III. MIX PROPORTION

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 study the percentage of nanoparticle were used at 0.5%, 1%, and 1.5% by weight of cement.

©IJRASET (UGC Approved Journal): All Rights are Reserved

A. *Sample*

The blended mortar mix was prepared by mixing cement, sand and nanoparticle of zinc oxide. After mixing the materials the paste was filled in cube moulds of size 70.6 mm x 70.6 mm x 70.6 mm. and removed these cubes after 24 hr. and put into water tank for curing up to 7,14,and 28 days. Eighty numbers of cubes were cast for this study,

IV. METHODOLOGY AND EXPERIMENTS

A. *Testing Procedure*

Cement with partially replacement by nanoparticle zinc oxide is used in the blended mortar mix design. Due to large surface energy of nanoparticles are not easy to equally disperse. Thus mixing was performed as follows: The NZnO particles and superplasticizer were mixed with water in the ultrasonic water bath for 1 minute. Cement was added with this mixture and mixed at medium speed. The sand was 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 length 70.6 mm x 70.6 mm x 70.6 mm have been used for compressive and durability take a look at. Nine specimens of each type for compressive power take a look at and 8 specimens for sturdiness were prepared and all specimens had been cured in water tank for 7, 14 and 28 days. Compressive take a look at have been finished in keeping with ASTM C109.

Table 4: Design Mix Proportions for Mortar

Sample	Description of mortar	Mix proportion for mortar (1:2)				
		W/B ratio	Cement	Sand	NP	SP % of cement
Control(A)	Conventional mortar	0.35	1	2	-	1
$NZ_{0.5}$ (A_1)	0.5% cement replacement by NZnO	0.35	0.95	2	0.05	1
NZ_1 (A_2)	1% cement replacement by NZnO	0.35	0.9	2	0.1	1
$NZ_{1.5}$ (A_3)	1.5% cement replacement by NZnO	0.35	0.85	2	0.15	1

Table 5: Design Mix proportion for mortar

Sample	Description of mortar	Mix proportion for mortar (1:3)				
		W/B ratio	Cement	Sand	NP	SP % of cement
Control (B)	Conventional mortar	0.35	1	3	-	1
$NZ_{0.5}$ (B_1)	0.5% cement replacement by NZnO	0.35	0.95	3	0.05	1
NZ_1 (B_2)	1% cement replacement by NZnO	0.35	0.9	3	0.1	1
$NZ_{1.5}$ (B_3)	1.5% cement replacement by NZnO	0.35	0.85	3	0.15	1

B. *Durability*

durability of mortar is vital for the satisfactory performance of structure throughout its duration. In this study after 28 days curing of cubes a salt cycles tests were conducted by 10% concentrated sodium chloride solution. In this test cycle of soaking and drying of samples was carried out. Due to 10% sodium chloride solution weight get reduced gradually of the specimens, when weight loss exceed 2% of the original weight then soaking/drying was stopped.

V. EXPERIMENTAL RESULTS AND DISCUSSION

©IJRASET (UGC Approved Journal): All Rights are Reserved

A. Compressive Strength

Results of compressive strength after 7, 14 and 28 days are shown in table-6. Cement mortar containing 0.5%, 1% and 1.5% of nanoparticle 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 compressive strength at 7, 14 and 28 days increases upto 1% ZnO nanoparticles and decreases the compressive strength at 1.5% of NZnO

Table 6**:** Compressive strength of mortar

Sample	Compressive strength of mortar (MPa)			
Type	7 days	14 days	28 days	% of Enhancement
A	24.33	34.33	38.2	-
B	18.13	24.46	27.93	-
A_1	27.46	37.56	41.73	9.24
A_2	28.33	38.46	42.8	12.04
A_3	29.06	40.2	44.8	17.27
B_1	19.33	26.4	29.46	5.42
B_2	19.46	26.73	30.05	7.59
B_3	18.86	25.66	29.53	5.72

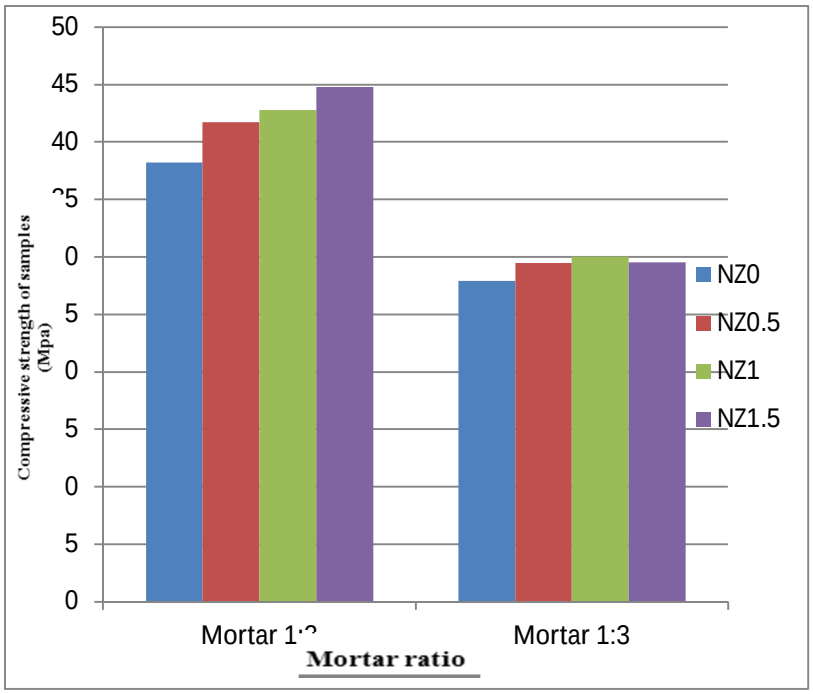


Figure 1: column chart of compressive strength of cement mortar

©IJRASET (UGC Approved Journal): All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VII, July 2017- Available at www.ijraset.com

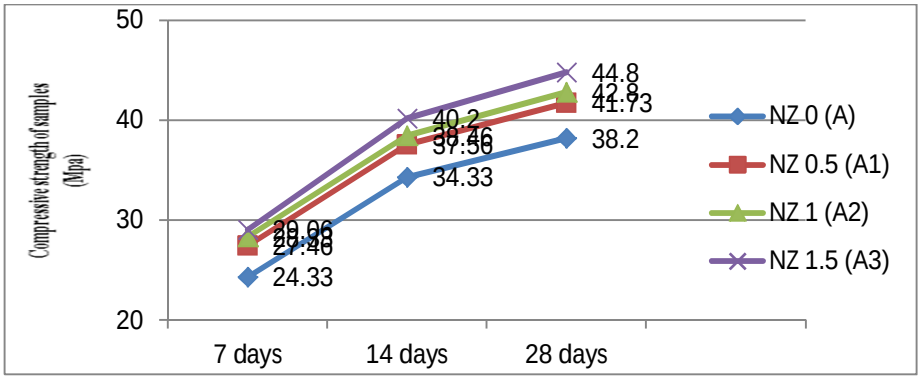


Figure 2: Typical compressive strength curve of cement mortar 1:2

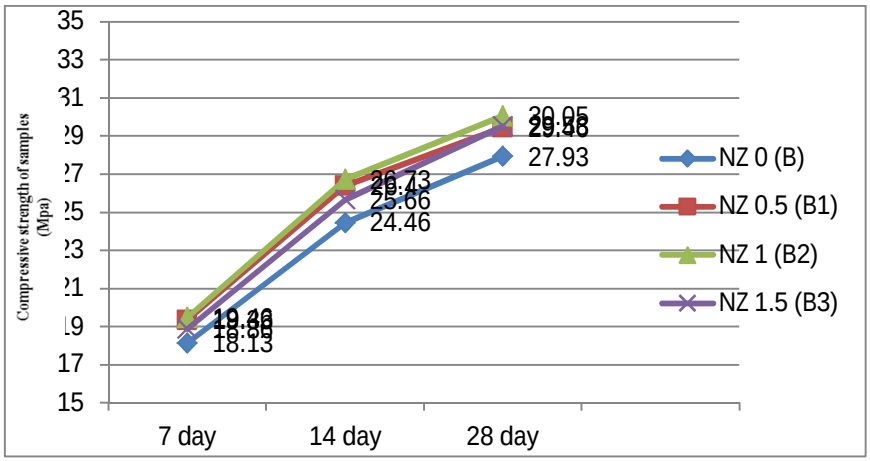


Figure 3: Typical compressive strength curve of cement mortar 1:3

B. Durability

After 28 days curing of cubes a salt cycles tests were conducted by 10% concentrated sodium chloride solution. In this test cycle of soaking and drying of samples are carried out. Result of durability shown in table-7 and table-8. Cement mortar of 1:2 containing 0.5%, 1% and 1.5% of nanoparticle are increase the durability (cycle) of blended mortar compare to control mortar. In the case of mix mortar 1:3 sample having 0.5% and 1% Zno nanoparticles increases the durability (cycle) but when increased ZnO particles upto 1.5% the durability (cycle) of mortar slightly decreases but more than control mortar.

Table7: Durability cycle for Mortar 1:2

Sample	Description of mortar	Dry Weight of mortar (gm)					
		0 cycle	5 cycle	10 cycle	15 cycle	20 cycle	25 cycle
Control(A)	Conventional mortar	820	820	810	802	-	-
$NZ_{0.5}$ (A_1)	0.5% cement replacement by NZnO	815	815	804	800	-	-
NZ_1 (A_2)	1% cement replacement by NZnO	825	825	820	812	808	-
$NZ_{1.5}$ (A_3)	1.5% cement replacement by NZnO	815	815	813	807	800	-

Table8: Durability cycle for Mortar 1:3

©IJRASET (UGC Approved Journal): All Rights are Reserved

Sample	Description of mortar	Dry Weight of sample (gm)				
		0 cycle	5 cycle	10 cycle	15 cycle	20 cycle
Control(B)	Conventional mortar	810	805	798	-	-
$NZ_{0.5}$ (B_1)	0.5% cement replacement by NZnO	795	792	786	779	-
NZ_1 (B_2)	1% cement replacement by NZnO	790	786	780	776	-
$NZ_{1.5}$ (B_3)	1.5% cement replacement by NZnO	795	793	788	783	-

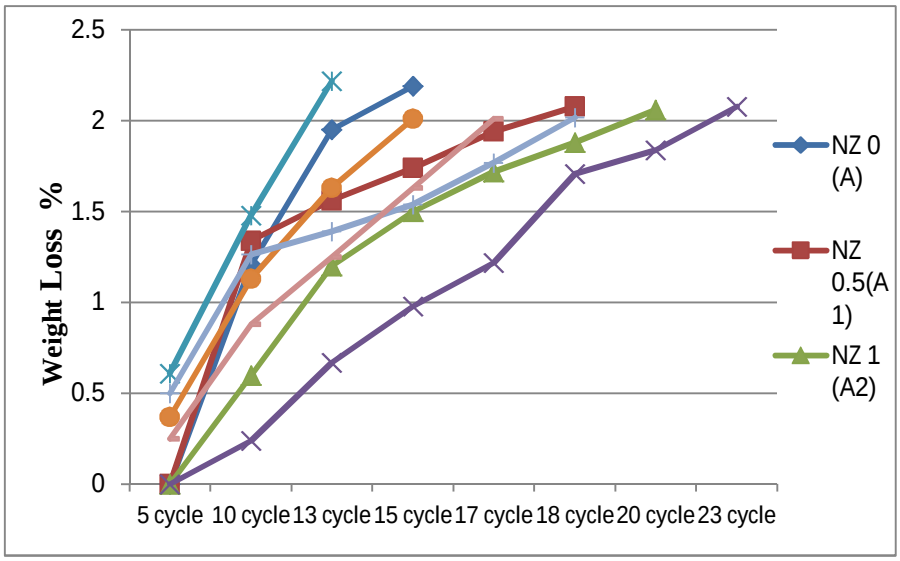


Figure 4: Typical weight-loss curves for cement mortars in 10% NaCl solution

V. CONCLUSION

Based on the experimental Result it is discovered that NZnO particle enhance the compressive energy and sturdiness of combined mortar. The compressive energy of mortar mix 1:2 at 1.5% NZnO compressive strength increases by 17.27% and for mortar mix ratio 1:3 at 1% NZnO compressive strength increases by 7.62% i.e. higher than control mortar. Durability of blended mortar also improved. nanoparticles 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 essential.

REFERENCES

[1] Albashir M. Hashim , G. Alseed Hashim and Abdalmajed 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 as Cementitious 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] Madandoust Rahmat,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

©IJRASET (UGC Approved Journal): All Rights are Reserved

[7] Mohseni Ehsan, "Single and combined effects of nano-SiO_2, nano-Al_2O_3 and nano-TiO_2 on the 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, Shadi Riahi, Shirin Riahi, Seyedeh Fatemeh Shamekhi 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.

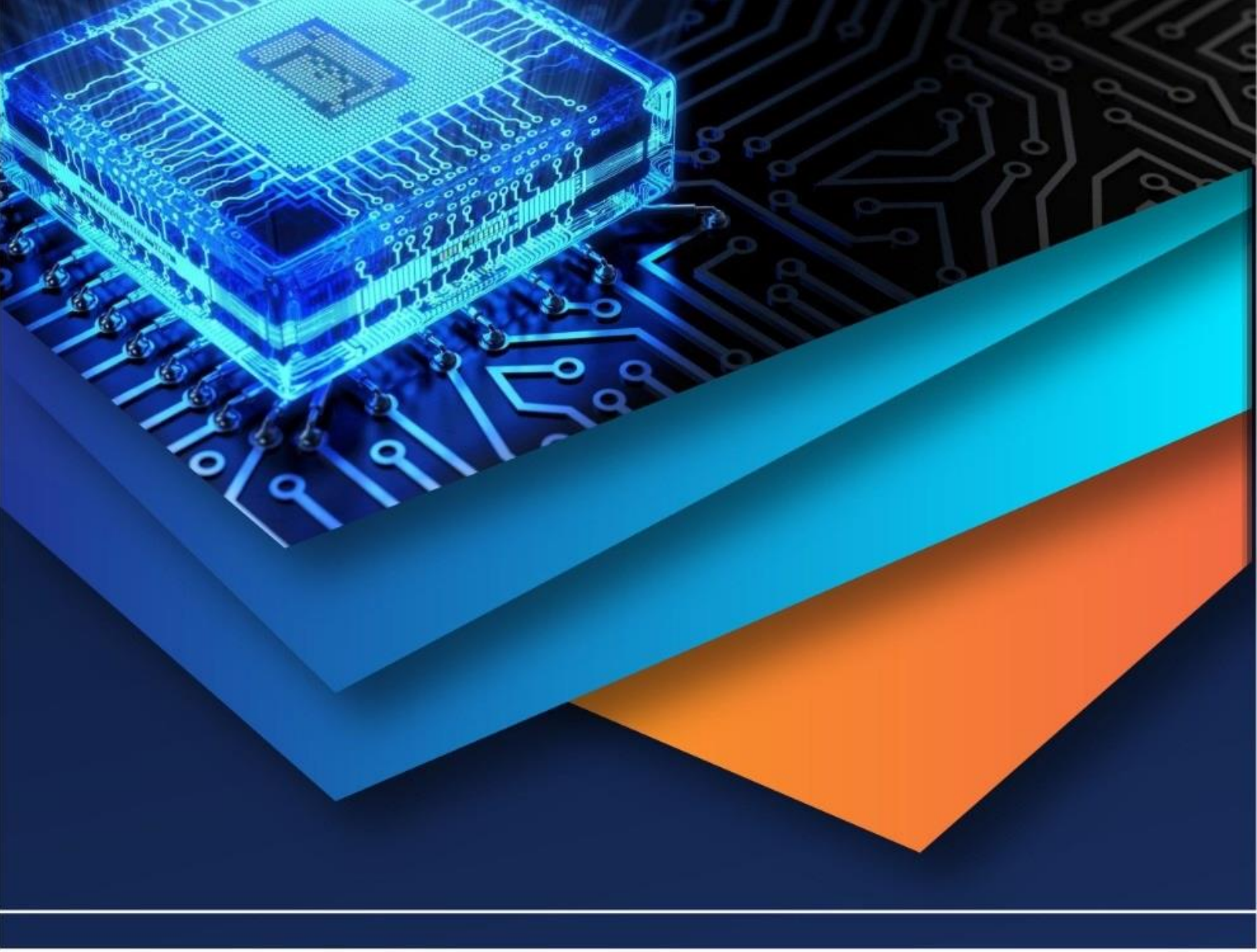
[9] Nazari Ali and Riahi Shadi, "The Effects of ZnO2 nanoparticles on strength Assessments and water permeability of concrete in different curing media", Journal of material research vol. 14 (2011).

[10] Nivethitha D. and Dharmar S., "Effect of Zinc Oxide Nanoparticle on Strength of Cement 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] 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).

©IJRASET (UGC Approved Journal): All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)