IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Review On Partial Replacement of Cement By Nano-Silica Use By Concrete

[1]Shubham K Khilare, [1]Ganesh R Bhandalkar, [1]Vikas M Putage, [2]D.W. Gawatre

Faculty Of Department of Civil Engineering, Sinhagad Academy Of Engineering, Pune (SPPU Pune-43) India

Abstract: The utilization of nano-silica as a partial replacement for cement in concrete has emerged as a promising avenue in construction materials research. This project aims to investigate the effects of incorporating nano-silica on the properties and performance of concrete. Nano-silica, with its high surface area and pozzolanic reactivity, offers the potential to enhance the strength, durability, and microstructure of concrete while reducing environmental impacts associated with cement production. Through comprehensive experimental studies, this project will assess the influence of varying nano-silica dosages on the mechanical strength, workability, permeability, and microstructural characteristics of concrete. Additionally, environmental and economic analyses will be conducted to evaluate the feasibility and sustainability of adopting nano-silica-modified concrete in construction practices. The findings of this research endeavor are expected to contribute valuable insights into optimizing concrete mix designs for enhanced performance and reduced environmental footprint.

Index Terms **-** Nano-silica, Concrete, Cement replacement, Strength, Durability, Microstructure, Sustainability, Pozzolanic reactivity.

I. INTRODUCTION

1.1 Background:

India at present is a fast-developing country that requires demands to increase infrastructure facilities along with the growth of population. Due to the increased population, the demand for land for housing is increasing day by day. To fulfill the need for massive construction work the amount concrete required is keep on increasing. The major part of concrete production is solely depending on the Cement. It is the one of the major ingredients of making concrete. The production of cement has some adverse effect on environment . It is impossible to envisage a modern life without cement. Cement is an extremely important construction material used for housing and infrastructure development and a key to economic growth. Cement demand is directly associated to economic growth and many growing economies are striving for rapid infrastructure development which underlines the tremendous growth in cement production

1.The cement industry plays a major role in improving living standard all over the world by creating direct employment and providing multiple cascading economic benefits to associated industries. Despite its popularity and profitability, the cement industry faces many challenges due to environmental concerns and sustainability issues

2.The cement industry is an energy intensive and significant contributor to climate change. The major environment health and safety issues associated with cement production are emissions to air and energy use. Cement manufacturing requires huge amount of nonrenewable resources like raw material and fossil fuels. It is estimated that 5-6% of all carbon dioxide greenhouse gases generated by human activities originates from cement production. Raw material and Energy consumption result in emissions to air which include dust and gases. The exhaust gases from a cement kiln contains are nitrogen oxides (NOx), carbon dioxide, water, oxygen and small quantities of dust, chlorides, fluorides, sulfur dioxide, carbon monoxide, and still smaller quantities of organic compounds and heavy metals.

It is well known fact that air pollution is hazardous to environment and human health. Due to infrastructure developmental activities cement industry is flourishing and resulting in the environmental deterioration and in turn degradation of the human health worldwide.

The gaseous and particulate emissions from cement plants are degrading air quality and thus creating considerable environmental pollution especially air pollution. Recent studies and researches have listed the cement industry as one of the major contributors in global warming and climate change. Literature reviewed in this study shows the clear picture of dire consequences of emissions from cement manufacturing for rapid infrastructure growth and economic development. From this review it can be concluded that cement industry causes a tremendous harm to ecology and human health. The main environment and health concerns have identified are significant amount of fine dust and gaseous emissions. Gaseous emissions can have major impact on surroundings and ecology resulting in deteriorated environment. Workers and communities' exposure to dust emission is associated with numerous health issues.

Nano silica

Colloidal silica (silicon dioxide) nanoparticles are an important class of nanomaterials with hundreds of thousands of tons produced annually for a wide range of applications including abrasives, sorbents, catalysis, filtration, electronics, textiles and fabrics, and paints and coatings. At nincompoops, we offer a selection of silica nanomaterials as standard products, including solid silica nanoparticles, mesoporous

silica nanoparticles, and silica shelled metal nanoparticles. We are highly skilled at modifying silica surfaces and fabricating a variety of silica morphologies on a custom basis.

II. LITERATURE REVIEW

2.1.1 Mohammed BS (2017): "A Review on Nano-Silica Based Concrete." J Nanomed Nanosci: JNAN128. DOI: 10.29011/JNAN-128. 10002: In this paper it was depicted that Nano silica improve the mechanical and durability properties due to its physico chemical relative characteristics. Nano – silica improves the durability and strength But contrary to that reduces workability for which we have to use superplasticizer.

2.1.2 Kaffayatullah Khan (2022): "Nano-Silica-Modified Concrete: A Bibliographic Analysis and Comprehensive Review of Material Properties" Nanomaterials 2022, 12, 1989. https://doi.org/10.3390/nano1212198 https://www.mdpi.com/journal/nanomaterials In this paper the literature on nano silica modified concrete to analyse it using VOS viewer software. We found that strength and durability increased most at 3% and then started to decline. Due to increase in NS% after 3% pozzolonic activity increases causing microcracking and loss of strength

2.1.3 A Paktiawal (2020): "Nano-Silica and its Role on Performance of Cement Concrete A Review of Experimental Investigation" IOP Conf. Series: Earth and Environmental Science 614 (2020) 012085 IOP Publishing doi:10.1088/1755-1315/614/1/012085. In this paper it mainly focusing on basic technology of cementitious material at nano level.it mainly aimed to enhance durability and strength. Utilization of nano-SiO2 by partial replacement of cement significantly increase the hydration of the cemnt matrix and influences setting time of concrete.

2.1.4 Pandiaraj Karthigai Priya (2021): "Effect of nano silica on the properties of concrete and mortar – A state of art" International Review of Applied Sciences and Engineering 13 (2022) 1, 70–79 DOI: 10.1556/1848.2021.00309. In this paper reviews the past studies in which nano silica is used in various building materials and various replacement materials , different materials and various tests has been studied. Different materials, varying percentage of replacement material has been used and various tests have been studied using various research data available.

2.1.5 Ashtar S. Al-Luhybi(2020): " The Influence of Nano-Silica on the Properties and Microstructure of Lightweight Concrete: a Review" To cite this article: Ashtar S. Al-Luhybi and Diyar Altalabani 2021 IOP Conf. Ser.: Mater. Sci. Eng. 1094 012075 In this paper Nano technology materials has increased strength and enhanced resistance behavior of concrete and its mechanical properties in light weight concrete. Nano-silica improves behaviour and durability of light weight concrete, because small size of material reduced the size of voids within the concrete.

2.1.6 D. S Teja (2019): "An Experimental Study on Effect of Nano Silica and behavior of OPC and Blended cement" Pramana Research Journal, Volume 9, Issue 8, 2019, ISSN NO: 2249- 2976. In this paper the objective is to determine the strength of materials by using nano silicaand also comparision of OPC and blended cement . Upto 3.5% replacement of nano-silicashould increase the strength and at 5.5% and 7.5% of nano-silica decreases the strength.

2.1.7 Akash Kumar (2018): "Effect of Nano Silica on the Fresh and Hardened Properties of Cement Mortar" International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 13 (2018) pp. 11183-11188 © Research India Publications. http://www.ripublication.com. In this paper the effect of nano silica on fresh properties, harden properties of cement mortar. It also been determined that with various percentage of nano silica can effect the strength. On addition of nano-silica there is a substantial increase in the 7 days strength in cement mortar compared to 28 days increase in strength.

2.1.8 Sarade Rutuja (2017): "Review Paper on Multifunctional use of Nano Silica in Concrete" International Journal of Engineering Science and Computing, April 2017 http://ijesc.org/ In this paper it concluded that nano-silica concrete could reduce emission of co2in atmosphere by using nano silica and also improvement in permiability. The average increase in compressive strength upto 10%, 14.93%, 19% in 3 days, 7days , 28days respectively .

2.1.9 Karthika P (2016): "An Experimental Study on Strength & Durability of Concrete Using Partial Replacement of Cement with Nano Silica" International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 171 ISSN 2229-5518 In this paper the main focuse is given to compressive , tensile and flexural strength by adding nano silica and reduction in corrosion. At 2% Of nano-silica It increases the compressive strength upto 40%, Tensile strength upto 15%, Flexural strength upto 35% and increases resistance to corrosion.

2.1.10 Mohammed Ayub Ghori (2021): "An Experimental Investigation on the Effect of Nano- Silica Particles on the Properties of Concrete" Volume: 08 Issue: 04 | Apr 2021 www.irjet.net. In this paper the nano silica Is been used to investigate the effect of it on properties of concrete . A partial replacement for cement in the range of 0.5%, 1%, 1.5%, 2% weight of cement for M30 mix . Superplasticizer has been used to maintain the workability of concrete.Highest strength gained was 18.3% at 3% of NS%.

III. METHODOLOGY

With reference to the extensive literature review conducted, the methodology of project work is established. In this project, all the investigation on Nano – Silica based concrete is done on M30 grade of concrete. The main aim in this project is to compare the fresh and hardened properties of normal concrete and Nano – silica baesd concrete at various volume fractions of basalt fibers. The material tests required to obtain the mix design of concrete were carried out in the laboratory. The mix design for M30 concrete is obtained using the IS Standard method of design. The material used are: Cement used is OPC 53 grade, locally available Crushed Sand and 20mm Coarse aggregates. In this design 2.75% , 3% and 3.25 % of cement content is replaced by addition of Nano – Silica , Also 1% of Polypropelene Fibre.

The experimental investigations carried out on Nano - Silica based concrete are: Cubic compressive strength, tensile strength / Flexural strength (modulus of rupture), and carbonation test . The volume fractions of Nano - Silica used were 2.75% 3% and 3.25% by weight of total binder material(cement). The strengths of Nano – Silica based concrete are compared with the strengths of controlled (plain) concrete. The silica were randomly oriented and dispersed with concrete.

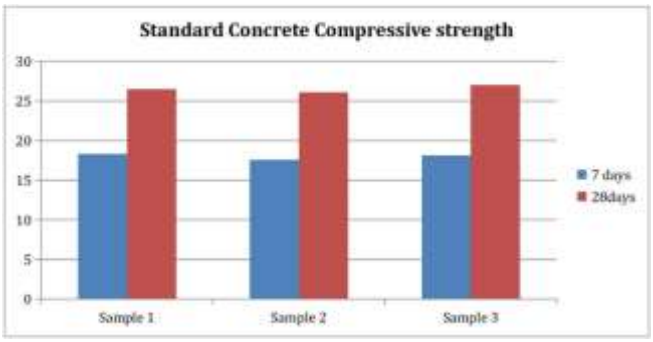
The cubic compressive strengths are compared for 7 days and 28 days curing period. The tensile strength / flexural strength are carried out only for 28 days curing period. In this research work 24 cubes, and 8 beams were casted for different volume fractions of Nano – Silica and polypropelene fibre . Thus in this project, a total of 44 specimens are used.

IV. RESULT

The previous chapter discussed the experimental test conducted on concrete in partial replacement of cement by nano silica and polypropylene fiber This chapter presents the experimental result obtained from the test conducted and discusses about the performance and behavior of nano silica in concrete. All the specimen are designated

Sr.No. (M25 grade of concrete)	Compressive strength test (7 days)	Compressive strengthtest (28 days)
1	18.3	26.51
2	17.59	26.12
3	18.12	27.01
Average	18.003 Mpa	26.54 Mpa

Table No. 1 Test Result



Bar chart No. 1 Standard compressive strength

NS percentages	Compressive strength test (7 days)	Average	Compressive strength test (28 days)	Average	Increase in Strength
	20.38		30.39		
2.75%	20.433	20.47 Mpa	27.34	29.76 Mpa	19.04%
	20.61		31.556		
	20.739		31.87		
3 %	20.84	20.866 Mpa	31.52	31.78 Mpa	27.12%
	21.02		31.96		
	21.20		32.96		
3.25 %	21.87	21.56 Mpa	32.64	32.90 Mpa	31.06%
	21.62		33.12		

Table No. 2 Compressive strength test reading

CONCLUSION

By the use nano-silica and polypropylene fiber we have noticed the increase in compressive strength. Out of three percentages of nano-silica we conclude that 3.25% has shown increase in compressive strength. By using 3.25% of nano silica for partial replacement of cement we got 31.0 % increase in compressive strength as compared to traditional concrete and by using 2.75 % of nano-silica we got 19.04 % increase in compressive strength. Out of three percentages of nano-silica we conclude that 3.25% has shown most increase in flexural strength. By using 3.25% of nano silica for partial replacement of cement we got 38.88 % increase in flexural strength as compared to traditional concrete andby using 2.75 % of nano-silica we got 16.66 % increase in compressive strength. We can use nano-silica as good partial replacement for cement as it is hazardous to environment and increase strength of concrete considerably.

REFERENCES

1. Mohammed BS (2017): "A Review on Nano-Silica Based Concrete." JNanomed Nanosci: JNAN128. DOI: 10.29011/JNAN-128. 10002
2. Kaffayatullah Khan (2022): "Nano-Silica-Modified Concrete: A Bibliographic Analysis and Comprehensive Review of Material Properties" Nanomaterials 2022, 12, 1989.https://doi.org/10.3390/nano1212198 https://www.mdpi.com/journal/nanomaterials
3. A Paktiawal (2020): "Nano-Silica and its Role on Performance of Cement Concrete A Review of Experimental Investigation" IOP Conf. Series: Earth and Environmental Science 614 (2020) 012085 IOP Publishing doi:10.1088/1755- 1315/614/1/012085
4. Pandiaraj Karthigai Priya (2021): "Effect of nano silica on the properties of concrete and mortar – A state of art" International Review of Applied Sciences and Engineering 13 (2022) 1, 70–79 DOI: 10.1556/1848.2021.00309
5. Ashtar S. Al-Luhybi(2020) : " The Influence of Nano-Silica on the Properties and Microstructure of Lightweight Concrete: a Review" To cite this article: Ashtar S. Al-Luhybi and Diyar Altalabani 2021 IOP Conf. Ser.: Mater. Sci. Eng. 1094 012075
6. Mohammed BS (2017): "A Review on Nano-Silica Based Concrete." J Nanomed Nanosci: JNAN128. DOI: 10.29011/JNAN-128. 10002
7. Kaffayatullah Khan (2022): "Nano-Silica-Modified Concrete: A Bibliographic Analysis and Comprehensive Review of Material Properties" Nanomaterials 2022, 12,1989.https://doi.org/10.3390/nano1212198 https://www.mdpi.com/journal/nanomaterials
8. A Paktiawal (2020): "Nano-Silica and its Role on Performance of Cement Concrete a Review of Experimental Investigation" IOP Conf. Series: Earth and Environmental Science 614 (2020) 012085 IOP Publishing doi:10.1088/1755- 1315/614/1/012085
9. D.W.Gawatre, "To Improve Mechanical Properties of Concrete Paver Blocks", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 14, Issue 3, May-June 2017. Pp 147-151. e- ISSN 2278-1684,p-ISSN 2320-334X.
10. D.W.Gawatre, "Manufacture of Paver Block using Partial Replacement of Construction and Demolition Concrete Waste", International Journal of Pure and Applied Research in Engineering and technology (IJPRET), Volume (9):11-18. 01st May 2016. Pp 11-18. ISSN: 2319-507X.
11. D.W.Gawatre, "Optimization of Artificial Sand in Concrete", International Journal of Advances in Mechanical & Civil Engineering (IJAMCE), Volume 3, Issue 3, June 2016.Pp 69-71. ISSN 2394-2827.
12. D.W.Gawatre, "Experimental Study on Flexible Concrete by using Polyurethane fiber", International Journal of Trend in Scientific Research and Development (IJTSRD), Volume 2, Issue 4, May-June-2018. Pp 744-747. P-ISSN 2456-6470.
13. D.W.Gawatre, "Effectiveness of Curing Compound on Concrete", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 14, Issue 3, May-June 2017. Pp 73-76. e- ISSN 2278-1684,p-ISSN 2320-334X.