International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 31-38, June-2023
https://doi.org/10.47001/IRJIET/2023.706006

Literature Review: Application of Nano Cement in High Volume Fly Ash Concrete

[1]Suhendro Trinugroho, [2]Alpri Wisnuaji

[1]Lecturer in a Civil Engineering Faculty, Muhammadiyah University of Surakarta, Central Java, Indonesia
[2]Student in Civil Engineering Faculty, Muhammadiyah University of Surakarta, Central Java, Indonesia

***Abstract* - Literature review on Nano Cement (NC) to illustrate that the application of Nao Cement (NC) on High Volume Fly Ash (HVFA) concrete can be applied. The results of its application can affect the durability, workability, and increase in concrete strength. In terms of concrete compressive strength, the use of Nano Cement (NC) as a partial replacement for cement is increasing, the higher the compressive strength in the concrete. So it can be concluded that the use of Nano Cement (NC) in concrete allows it to be applied or used, this is the goal from literature review research. Data collection was carried out by reviewing several Nano Cement (NC) related journals in the period between 2009-2022.**

Keywords: Nano cement, Durability, High Volume Fly Ash Concrete.

I. INTRODUCTION

The introduction of Nano technology has significantly influenced material science and caused major changes in materials. Currently, work in the construction world is growing rapidly with the increasing demand for concrete. Concrete is one of the materials most often used by humans today [1].

Portland cement is produced around 4 to 5 billion tons per year and is the most expensive ingredient in concrete. It is estimated that this cement is mass-produced every years. However, research on the use of nanomaterials to improve the mechanical properties and durability of cement-based materials has received a significant boost. Portland cement is partially replaced by nanomaterials such as carbon tube (NCT), Nano-SiO_2 (NS), Nano-Al_2HAl_3 (NA), graphene oxide (GO), NANO-TiO_2 (NT), Nano-clay (NC), and Nano-materials –ZnO_2(NZ), Nano-$CaCO_3$ and Nano-Fe_2HAl_3(NF) reduce CO_2 emissions, thereby improving the mechanical properties and durability of concrete. Today's increasing demand for ultra-high performance concrete (UHPC) creates opportunities for the application of nanotechnology in concrete. These nanoparticles in concrete are an alternative to hybrid fumed silica concrete (traditionally used in UHPC for better strength and durability). Due to limited materials and high costs. Nano Silica was designed to mimic the characteristics of silica, which has led to the development of a variety of other nano materials in cement-based admixtures.[2]

These nanoparticles can improve the quality of the cement matrix, and the introduction of these nanomaterials can produce concrete without changing the chemical composition of the material itself. Number of studies on the use of nanoparticles in concrete mixtures for the period 2009-2022. Nanocement in concrete mixes has been shown to improve concrete performance in Indonesia. Compared with the conventional mortar mixture with the same water-cement ratio, the compressive strength and flexural strength of this sample were significantly improved in the presence of Nano-SiO_2 and Nano-Fe_2O_3. Compared to materials engineering utilizing this nanotechnology, many studies have been done.[3] Nanocement research has been carried out to optimize the composition of the material and achieve very dense material densities. This density arises from the principle that nanoscale materials fill the pores. By using this Nano-cement, the compressive strength of concrete can be improved and a higher modulus of elasticity than ordinary concrete can be produced [4].

Researchers are currently very interested in the effect of using Nano materials as a substitute for cement in concrete. The materials/Nano particles are nano silica, Nano carbon tubes, Nano TiO_2, Nano Fe_2HAI_3 and Nano AI_2HI_3.

Due to its amorphous structure, high specific surface area and high purity, among all nanomaterials/particles, nanosilica is more suitable for the production of cement-based materials. It is a pozzolanic material with a dual action: by increasing nucleation, it improves the properties of the cement paste as a filler and also affects the properties of the cement paste due to the pozzolanic reaction.[5]

However, Nano-SiO_2 is amorphous, with smaller particle size and higher surface activity, so theoretically it can react with calcium hydroxide to generate calcium silicate hydrate (CSH) more efficiently. In addition, Nano-SiO_2 particles can directly fill the micropores between cement hydrationproducts, thereby improving the mechanical properties of cement.[6]

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 6, pp 31-38, June-2023

https://doi.org/10.47001/IRJIET/2023.706006

To further exploit Nano-SiO_2 sol on cement hydration, adopt XRD to analyze the mineral composition of the original cement stone and adjust the cement with 2% and 100% Nano-SiO_2 sol after processing for 1 day under high temperature.[6]

Nano-SiO_2 has been used to increase the strength, flexibility and aging resistance of polymers. The effect of Nano-SiO_2 on the mechanical properties of High-Volume Fly Ash High Strength Concrete (HFAC) has been studied. Comparisons were made between Fly Ash combining Nano-SiO_2, Fly Ash, and Nano-SiO_2 alone in terms of change in weight after immersion in a saturated lime solution. The addition of Nano-SiO_2 to high-volume high-strength concrete leads to an increase in strength. The pozzolanic activity of Nano-SiO_2 can activate Fly Ash, causing weight gain.[7]

The inclusion of fly ash (FA) in cement mortar was studied. The amount of powder used in all mixtures was 0.5, 1.25 and 2.5% by weight of the binder. The results showed that the addition of 1.25% of all types of oxide powders (NS, NA and NF) increased the compressive strength of the mortar compared to other proportions. Use of 1.25% Na powder increases compressive strength compared to conventional blends.[11]

The use of X-Ray Diffraction is implemented in these journals. X-Ray Diffraction (XRD) is one of the most widely applied engineering material characteristics. Apart from X-Ray Diffraction, Scanning Electron Microscopy (SEM) applications. Scanning Electron Microscopy (SEM) is an electron microscope technique that can produce detailed visual images of particles with high quality and spatial resolution.[12]

The purpose and objective of reviewing this journal is to find out the results of several research journals. To find out the increasing application of durability, workability and strength in concrete, comparisons between methods for making Nano Cement in several journals, in addition to explaining the application of Nano Cement as a mixture in making concrete. This journal review is presented as a reference in knowing how much Nano Cement is used as a material for concrete work.

II. METHOD

Method of the research used is a systematic literature review, which collects, evaluates, integrates and analyzes findings from various research journals on an issue or topic of interest systematically.

Table 1: Literature Review Table

TOPIC	AUTHORS
Durability properties of high volume fly ash concrete containing nano-silica	[1](SWM Supit and FUA Shaikh. 2015)
Influence of nano-TiO_2, nano-Fe_2O_3, Nanoclay and Nano-$CaCO_3$ on the properties of cement/geopolymer concrete	[2](JA Abdalla et. al. 2022)
The effect of Nano-cement content to the compressive strength of mortar	[3](P. Sabdonoa, F. Sustiawana, and DA Fadlillaha. 2014)
Engineering of SiO_2 Nanoparticles for Optimal Performance in Nano Cement-Based Materials	[4](K. Sobolev et. al. 2009)
Microstructure and Nanoscaled Characterization of HVFA Cement Paste Containing Nano-SiO^2 and Nano-$CaCO_3$	[8](FUA Shaikh, SWM Supit, and S. Barbhuiya. 2017)
Effect of Nano-silica addition into high volume fly ash–hydrated lime blended concrete	[9](C. Gunasekara. et. al. 2020)
Effect of Nano Flyash on Strength of Concrete	[10](PA G and JCM 2011)
Effect of Nano-Clay on Mechanical Properties and Microstructure of Ordinary Portland Cement Mortar Green Building Cladding/Plastering Materials View Project Durability of FRP Composites View Project.	[7](M. Morsy, S. Alsayed, and M. Aqel. 2010)
Application of Nano-Silica in Cement Mortar and Concrete. Smart Nanoconcretes and Cement-Based Materials: Properties, Modeling and Applications.	[11](S. Gupta. 2019)
Study on Strength and Durability Characteristics of Nano-Silica Based Blended Concrete.	[5](VV Praveen Kumar and S. Dey. 2022)
Comparison of the Properties between High-Volume Fly Ash Concrete and High-Volume Steel Slag Concrete under Temperature Matching Curing Conditions.	[16] (Mengxiao, Shi, Wang Qiang, and Zhou Zhikai. 2015)
The Effect of Nano-Cement Content to the Compressive Strength of Mortor.	[3](P. Sabdonoa, F. Sustiawana, and DA Fadlillaha. 2019)
Working Mechanism of Nano-SiO_2 Sol to Alleviate the Strength Decline of Oil Well Cement under High Temperature.	[6](C. Wang, X. Chen, W. Zhou, Y. Wang, Y. Xue, and F. Luo. 2019)

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 6, pp 31-38, June-2023

https://doi.org/10.47001/IRJIET/2023.706006

Literature review is a method applied to journal analysis that refers to previous journals and relates to the title used, namely Nanocement (NC) Research and Applications of Nanotechnology in Concrete Mixtures. The partially adopted journals are research journals conducted in 2009-2022. The data obtained is the method of making and mixing Nano Cement (NC) and the characteristics of the results of adding Nano Cement (NC). This study was reviewed to find out the results of each study regarding the application of the Nano Cement (NC) addition method to concrete.

The incoming sources used in conducting this Literature Review are data from national and international journals with the help of publish and perish applications based on Google Scholar data. The processing of data related to the research title.

This analysis will produce analysts who will be the results of the research discussion and then conclusions will be drawn from the results of the discussion.

Then data analysis was carried out in the form of implementation methods for making Nano Cement (NC) and comparing the results of the durability and workability of adding Nano Cement (NC) to concrete from the journal.

Nano Cement Manufacturing Method

Outcomes of this research are methods for fabricating nanomaterials using plasma arc, flame pyrolysis, chemical vapor deposition, electrodeposition, sol-gel synthesis, mechanical friction and using natural Nanosystems [13]. In chemical technology, sol-gel synthesis is a bottom-up production method widely used for nanoscale materials such as Nanoscale silica. The process involves the formation of a colloidal suspension (sol) and gelation of the sol to form a network in the continuous gel phase. Typically, trimethylethoxysilane or tetraethoxysilane (TMOS/TEOS) are used to synthesize Nanosilica.

The equation in the journal using X-Ray Diffraction (XRD) functions as an identification of the characteristics of the chemical composition contained in the Nano sample so that it can classify the type of Nano used in the study.

Scanning Electron Microscopy (SEM) is used to analyze the surface of the particles in order to obtain changes in the Nano and analyze the phase elements observed in the Nano structure. Furthermore, this Nano material is added to the test object in order to see its compressive strength.

Table 2: Percentage of use of Nano Cement and its compressive strength

Authors	Nano cement percentage	The percentage of other added ingredients	Compressive Strength (28 days)	units
[2](JA Abdulla et. al. 2022)	0%: 0.1%: 0.25%	Nano-$CaCO_3$ 1%	24	N/mm^2
[12](DA Fadlillah. et. al. 2014)	20%; 40%; 60%	PPC Cement 20%	56,570	N/mm^2
[14](FUA Shaikh and SWM Supit. 2014)	1.5% ; 1.7% ; 2.0%	Nano- $CaCO_3$ 8%	75.8	N/mm^2
[15](M. Solikin and B. Setiawan. 2017)	1% ; 8%	Nano-SiO_2 20%	48	N/mm^2
[16](S. Mengxiao, W. Qiang, and Z. Zhikai. 2015)	35%	AI_2O_3 6.33%	42.5	N/mm^2
[17](M. Oltulu and R. Şahin. 2013)	8.3%;1.6%;4.3%	Nano-Fe_2O_3 3.28%	49,54	N/mm^2
[18](HD Raghavendra Prasad and N. Sitaram. 2020)	0%;0.01%;0.025%;0.05%	Multi-walled Carbon Nano Tubes 0.6%	28.5	N/mm^2
[19](NB Singh, M. Kalra, and SK Saxena, 2017)	0.045%	Nano-Silica 2%	26,69	N/mm^2
[20](BW Jo, S. Chakraborty, and H. Kim, 2015)	1.7%;1.4%;0.9%	Nano-Fiber 2%	34,8	N/mm^2
[21](H. Yang et al., 2021)	3%1.8%	Nano-Silica 1%	25	N/mm^2
[22](AS Kadhim, AA Atiyah, and SA Salih, 2020)	0.36%; 3.14%; 6.85%	Nano-Cement Kiln Dust 1.3%	31.01	N/mm^2
[23](M. Kooshafar and H. Madani, 2020)	1%;3%;5%;7%	Nano-Silica 6.25%	57,23	N/mm^2

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 31-38, June-2023
https://doi.org/10.47001/IRJIET/2023.706006

[24](Z. Ren et al, 2021)	2%;0.5%	Nano-TiO_2 2%	43.88	N/mm^2
[25](A. Khaloo, MH Mobini, and P. Hosseini, 2016)	1.5%;0.75%	Nano-SiO_2 5%	33,2	N/mm^2
[26](A. Naji et. al, 2010)	0.5%; 1%; 1.5%; 2%	Nano-SiO_2 2.25%	30	N/mm^2
[27](F. Sanchez and K. Sobolev, 2010)	3%; 5%	Nano-AI_2O_3 5%	36,4	N/mm^2
[28](A. Nazari and S. Riahi, 2010)	1%; 2%	Nano-TiO_2 4%	35,2	N/mm^2
[29](H. Eskandari, M. Vaghefi, and K. Kowsari, 2015)	5%; 8%	Nano- Silica 2%	41,4	N/mm^2
[30](H. Du, S. Du, and X. Liu, 2015)	2.6%; 5.6%	Nano-SiO_2 2%	52	N/mm^2
[31](N. Farzadnia, et. al, 2015)	3%; 7%	Nano-Silica 1%	41.8	N/mm^2
[32](R. Chinthakunta, et. al, 2021)	3%; 5%	Silica Fume 10%	58	N/mm^2
[33](P. Aggarwal, RP Singh, and Y. Aggarwal, 2015)	7%	Nano- Silica 5%	52	N/mm^2
[34](E.Science, 2022)	0.2%	Nano Clay 3%	25	N/mm^2
[35](D. Prasad, S. Singla, and R. Garg, 2021)	1%; 2%; 3%	Nano Silica 2%	45	N/mm^2
[36](AN Saleh, et. al, 2021)	1%; 2%	Nano-SiO_2 2%	35	N/mm^2
[37](BB Mukharjee and S. V Barai, 2014)	3%	Nano Silica 3%	40	N/mm^2
[38] (C. Herath, C. Gunasekara, D. W. Law, and S. Setunge, 2021)	-	Nano Silica 1%;2%;3%	41,1	N/mm^2
[39] (S. A. Khafaga, 2019)	-	Nano- SiO_2 2%;5%	43,05	N/mm^2
[40] (S. Du, Y. Ge, and X. Shi, 2019)	-	Nano-Al_2O_3 3,97%	45	N/mm^2
[41] (M. Adamu, B. S. Mohammed, and M. Shahir Liew, 2018)	-	Nano-Silica 2,5%	43,13	N/mm^2
[42] (M. Adamu, et. al, 2022)	-	Nano-Silica 1%;2%	34	N/mm^2
[43] (L. G. Li, J. Y. Zheng, P. L. Ng, and A. K. H. Kwan,2020)	-	Nano-Silica 2,4%;4,8%	42	N/mm^2
[44] (R. Kancharla, et. al, 2021)	0,5%	Nano-Silica 1%;5%	40,7	N/mm^2
[45] (P. Xu, R. Shi, et. al, 2021)	1%	Nano-SiO_2 0,5%;1,5%	45	N/mm^2
[46] (J. W. Park, K. H. Kim, and K. Y. Ann, 2016)	-	Magnesia (MgO) 4,1%;3,3%;0,5%	42	N/mm^2
[47] (J. O. Okeniyi, A. P. I. Popoola, and E. T. Okeniyi, 2018)	0,075%	Nano-Li_2CO_3 0,1%;0,125	40	N/mm^2
[48] (T. Wang *et al.*, 2021)	1%	Nano-$CaCO_3$ 2%	42,5	N/mm^2
[49] (S. Srikanth *et al.*, 2021)	-	Nano-GGBS 30%;60%	82	N/mm^2
[50] (P. Zhang, et. al., 2014)	5%	-	36,5	N/mm^2
[51] (M. Adamu, B. S. Mohammed, N. Shafiq, and M. S. Liew, 2020)	-	Nano-Silica 3%;1%	42,5	N/mm^2
[52] (Z. Zhou, M. Sofi, J. Liu, S. Li, A. Zhong, and P. Mendis, 2021)	-	Nano C-S-H 4%;2%	39	N/mm^2
[53] (J. Sun, X. Shen, G. Tan, and J. E. Tanner, 2019)	-	Nano-SiO_2 2%	40,5	N/mm^2
[54] (S. S. Sankaranarayannan and J. R. Jagadesan, 2018)	-	Nano-SiO_2 2,4%	35	N/mm^2

III. RESULTS AND DISCUSSION

The researchers found that tests conducted in several journals had different levels of maximum compressive strength. This happens because the application makes a different test object, namely by making a concrete test object, so the composition of the material used is also different, then by adding the same Nano Cement (NC) content to make a test object with maximum durability. The compressive strength of concrete in this study achieves a better maximum value, but

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 31-38, June-2023
https://doi.org/10.47001/IRJIET/2023.706006

Nano Cement (NC) concrete has a higher density value because it has a denser pore density and the denser the pores, the higher the durability

IV. CONCLUSION

The conclusions that can be drawn from this literature review are how Nano Cement (NC) works and how to add Nano cement replacement technology to concrete for durability and resistance. In the manufacture of nanoparticles, the characteristics are obtained by using a Scanning Electron Miroscopy (SEM) tool to identify the surface characteristics of the nanoparticles.

Based on several studies conducted in the literature study, it was found that the use of basic materials for Nano Cement, with a large percentage of Nano cement, namely 20%, 40%, 60%, and 80% with compressive strength results of 53 MPa, 56,862 MPa, 57,445 MPa, respectively and 58.644 MPa [12]. From these results, not only using a mixture of Nano cement, there are other mixed ingredients including Nano $CaCO_3$, Nano SiO_2, Nano Silica Fume, Nano TiO_2, Nano-Fe_2O_3, Nano Multi-walled Carbon Nano Tubes , Multi-walled Carbon Nano Tubes, Nano clay, and Nano-Fiber. The percentage of Nano $CaCO_3$ is 8% with a compressive strength of 75.8 MPa, the percentage of Nano SiO_2 is 2.25% with a compressive strength of 30 MPa, the percentage of Nano silica Fume is 10% with a compressive strength of 58 MPa, Nano TiO_2 is 4% with a compressive strength of 35.2 MPa, Nano Fe_2O_3 which is 3.28% with a compressive strength of 49.54 MPa, Nano Al_2O_3 which is 5% with a compressive strength of 36.4 MPa, Multi-walled Carbon Nano Tubes which is 0.6% with a compressive strength of 28.5 MPa , Nanoclay which is 3% with a compressive strength of 25 MPa, and Nano fiber with 3% has a compressive strength of 38.4 MPa. With these results, the most economical review is obtained with research on Nano-based mixtures, which have a percentage of 0.6% [18]. And the results of this review also get the results from the journal which has the highest compressive strength with a compressive strength of 75.8 MPa with a percentage ratio of mixed materials other than Nano cement, Nano CaCO3 (8%) [14].

This, in this literature review, it does not only utilize Nano-cement admixtures, but uses a variety of other admixtures that have a role in the proportion of the mix to obtain the strength and durability of the concrete test object.

REFERENCES

[1] S. W. M. Supit and F. U. A. Shaikh, "Durability properties of high volume fly ash concrete containing nano-silica," Mater. Struct. Constr., vol. 48, no. 8, pp. 2431–2445, 2015, doi: 10.1617/s11527-014-0329-0.

[2] J. A. Abdalla, B. S. Thomas, R. A. Hawileh, J. Yang, B. B. Jindal, and E. Ariyachandra, "Influence of nano-TiO_2, nano-Fe2O3, nanoclay and nano-$CaCO_3$ on the properties of cement/geopolymer concrete," Clean. Mater., vol. 4, no. November 2021, 2022, doi: 10.1016/j.clema.2022.100061.

[3] P. Sabdonoa, F. Sustiawana, and D. A. Fadlillaha, "The effect of nano-cement content to the compressive strength of mortor," Procedia Eng., vol. 95, no. Scescm, pp. 386–395, 2014, doi: 10.1016/j.proeng.2014.12.197.

[4] K. Sobolev, I. Flores, L. M. Torres-Martinez, P. L. Valdez, E. Zarazua, and E. L. Cuellar, "Engineering of SiO_2 Nanoparticles for Optimal Performance in Nano Cement-Based Materials," Nanotechnol. Constr. 3, pp. 139–148, 2009, doi: 10.1007/978-3-642-00980-8_18.

[5] V. V. Praveen Kumar and S. Dey, "Study on strength and durability characteristics of nano-silica based blended concrete," Hybrid Adv., vol. 2, no. July 2022, p. 100011, 2023, doi: 10.1016/j.hybadv.2022.100011.

[6] C. Wang, X. Chen, W. Zhou, Y. Wang, Y. Xue, and F. Luo, "Working mechanism of nano-SiO_2 sol to alleviate the strength decline of oil well cement under high temperature," Nat. Gas Ind. B, vol. 6, no. 5, pp. 517–523, 2019, doi: 10.1016/j.ngib.2019.03.008.

[7] M. Morsy, S. Alsayed, and M. Aqel, "Effect of nano-clay on mechanical properties and microstructure of ordinary Portland cement mortar Green Building Cladding/Plastering Materials View project Durability of FRP Composites View project," Int. J. Civ. Environ. Eng., vol. 10, no. 01, pp. 21–25, 2010, [Online]. Available: https://www.researchgate.net/publication/284429895

[8] F. U. A. Shaikh, S. W. M. Supit, and S. Barbhuiya, "Microstructure and Nanoscaled Characterization of HVFA Cement Paste Containing Nano-SiO_2 and Nano-$CaCO_3$," J. Mater. Civ. Eng., vol. 29, no. 8, pp. 1–10, 2017, doi: 10.1061/(asce)mt.1943-5533.0001898.

[9] C. Gunasekara, M. Sandanayake, Z. Zhou, D. W. Law, and S. Setunge, "Effect of nano-silica addition into high volume fly ash–hydrated lime blended concrete," Constr. Build. Mater., vol. 253, p. 119205, 2020, doi: 10.1016/j.conbuildmat.2020.119205.

[10] P. A. G and J. C. M, "Effect of Nano Flyash on Strength of Concrete," Int. Civ. Struct. Eng., vol. 2, no. 2, pp. 475–482, 2011.

[11] S. Gupta, Application of nano-silica in cement mortar and concrete. Elsevier Inc., 2019. doi: 10.1016/B978-0-12-817854-6.00027-1.

[12] D. A. Fadlillah, F. Sustiawan, H. A. Lie, and Purwanto, "Pengaruh Komposisi Nano Semen Terhadap Kuat Tekan Mortar," J. Karya Tek. Sipil, vol. 3, no. 4, pp.

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 31-38, June-2023
https://doi.org/10.47001/IRJIET/2023.706006

1031–1042, 2014, [Online]. Available: http://ejournal-s1.undip.ac.id/index.php/jkts

[13] G. Li, "Properties of high-volume fly ash concrete incorporating nano-SiO2," Cem. Concr. Res., vol. 34, no. 6, pp. 1043–1049, 2004, doi: 10.1016/j.cemconres.2003.11.013.

[14] F. U. A. Shaikh and S. W. M. Supit, "Mechanical and durability properties of high volume fly ash (HVFA) concrete containing calcium carbonate ($CaCO_3$) nanoparticles," Constr. Build. Mater., vol. 70, pp. 309–321, 2014, doi: 10.1016/j.conbuildmat.2014.07.099.

[15] M. Solikin and B. Setiawan, "The Effects of Design Strength, Fly Ash Content and Curing Method on Compressive Strength of High Volume Fly Ash Concrete: A Design of Experimental," MATEC Web Conf., vol. 103, pp. 1–8, 2017, doi: 10.1051/matecconf/201710301003.

[16] S. Mengxiao, W. Qiang, and Z. Zhikai, "Comparison of the properties between high-volume fly ash concrete and high-volume steel slag concrete under temperature matching curing condition," Constr. Build. Mater., vol. 98, pp. 649–655, 2015, doi: 10.1016/j.conbuildmat.2015.08.134.

[17] M. Oltulu and R. Şahin, "Effect of nano-SiO_2, nano-Al_2O_3 and nano-Fe_2O_3 powders on compressive strengths and capillary water absorption of cement mortar containing fly ash: A comparative study," Energy Build., vol. 58, pp. 292–301, 2013, doi: 10.1016/j.enbuild.2012.12.014.

[18] H. D. Raghavendra Prasad and N. Sitaram, "Performance of nano materials for the strength development in concrete cube used as Partial replacement for cement at different temperatures," Mater. Today Proc., vol. 45, pp. 7253–7258, 2020, doi: 10.1016/j.matpr.2021.03.415.

[19] N. B. Singh, M. Kalra, and S. K. Saxena, "Nanoscience of Cement and Concrete," Mater. Today Proc., vol. 4, no. 4, pp. 5478–5487, 2017, doi: 10.1016/j.matpr.2017.06.003.

[20] B. W. Jo, S. Chakraborty, and H. Kim, "Prediction of the curing time to achieve maturity of the nano cement based concrete using the Weibull distribution model," Constr. Build. Mater., vol. 84, pp. 307–314, 2015, doi: 10.1016/j.conbuildmat.2015.03.037.

[21] H. Yang et al., "Effects of nano silica on the properties of cement-based materials: A comprehensive review," Constr. Build. Mater., vol. 282, p. 122715, 2021, doi: 10.1016/j.conbuildmat.2021.122715.

[22] A.S. Kadhim, A. A. Atiyah, and S. A. Salih, "Properties of self-compacting mortar containing nano cement kiln dust," Mater. Today Proc., vol. 20, no. xxxx, pp. 499–504, 2020, doi: 10.1016/j.matpr.2019.09.177.

[23] M. Kooshafar and H. Madani, "An investigation on the influence of nano silica morphology on the characteristics of cement composites," J. Build. Eng., vol. 30, no. September 2019, p. 101293, 2020, doi: 10.1016/j.jobe.2020.101293.

[24] Z. Ren et al., "Optimizing the content of nano-SiO_2, nano-TiO_2 and nano-CaCO3 in Portland cement paste by response surface methodology," J. Build. Eng., vol. 35, no. September 2020, 2021, doi: 10.1016/j.jobe.2020.102073.

[25] A.Khaloo, M. H. Mobini, and P. Hosseini, "Influence of different types of nano-SiO_2 particles on properties of high-performance concrete," Constr. Build. Mater., vol. 113, pp. 188–201, 2016, doi: 10.1016/j.conbuildmat.2016.03.041.

[26] A.Naji, S. Abdul, F. Nora, A. Aziz, M. Amran, and M. Salleh, "Composites : Part B Experimental investigation of the size effects of SiO_2 nano-particles on the mechanical properties of binary blended concrete," Compos. Part B, vol. 41, no. 8, pp. 673–677, 2010, doi: 10.1016/j.compositesb.2010.08.003.

[27] F. Sanchez and K. Sobolev, "Nanotechnology in concrete – A review," Constr. Build. Mater., vol. 24, no. 11, pp. 2060–2071, 2010, doi: 10.1016/j.conbuildmat.2010.03.014.

[28] A.Nazari and S. Riahi, "The effect of TiO_2 nanoparticles on water permeability and thermal and mechanical properties of high strength self-compacting concrete," Mater. Sci. Eng. A, vol. 528, no. 2, pp. 756–763, 2010, doi: 10.1016/j.msea.2010.09.074.

[29] H. Eskandari, M. Vaghefi, and K. Kowsari, "Investigation of Mechanical and Durability Properties of Concrete Influenced by Hybrid Nano Silica and Micro Zeolite," Procedia Mater. Sci., vol. 11, pp. 594–599, 2015, doi: 10.1016/j.mspro.2015.11.084.

[30] H. Du, S. Du, and X. Liu, "Effect of nano-silica on the mechanical and transport properties of lightweight concrete," Constr. Build. Mater., vol. 82, pp. 114–122, 2015, doi: 10.1016/j.conbuildmat.2015.02.026.

[31] N. Farzadnia, H. Noorvand, A. Mohamed, F. Nora, and A. Aziz, "The effect of nano silica on short term drying shrinkage of POFA cement mortars," Constr. Build. Mater., vol. 95, pp. 636–646, 2015, doi: 10.1016/j.conbuildmat.2015.07.132.

[32] R. Chinthakunta, R. Durga, S. Rama, M. Chand, and J. Y. M, "Materials Today: Proceedings Performance evaluation of self-compacting concrete containing fly ash , silica fume and nano titanium oxide," Mater. Today Proc., vol. 43, pp. 2348–2354, 2021, doi: 10.1016/j.matpr.2021.01.681.

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 31-38, June-2023
https://doi.org/10.47001/IRJIET/2023.706006

[33] P. Aggarwal, R. P. Singh, and Y. Aggarwal, "Use of nano-silica in cement based materials — A review," 2015, doi: 10.1080/23311916.2015.1078018.

[34] E. Science, "The Impact of Nano Clay on Normal and High- Performance Concrete Characteristics: A Review The Impact of Nano Clay on Normal and High-Performance Concrete Characteristics: A Review," 2022, doi: 10.1088/1755-1315/961/1/012085.

[35] D. Prasad, S. Singla, and R. Garg, "Materials Today: Proceedings Microstructural and strength parameters of Nano-SiO_2 based cement composites," Mater. Today Proc., no. xxxx, pp. 2–6, 2021, doi: 10.1016/j.matpr.2021.04.276.

[36] A.N. Saleh, A. A. Attar, O. K. Ahmed, and S. S. Mustafa, "Results in Engineering," Results Eng., vol. 12, no. October, p. 100303, 2021, doi: 10.1016/j.rineng.2021.100303.

[37] B. B. Mukharjee and S. V Barai, "Influence of incorporation of nano-silica and recycled aggregates on compressive strength and microstructure of concrete," Constr. Build. Mater., vol. 71, pp. 570–578, 2014, doi: 10.1016/j.conbuildmat.2014.08.040.

[38] C. Herath, C. Gunasekara, D. W. Law, and S. Setunge, "Long term mechanical performance of nano-engineered high volume fly ash concrete," J. Build. Eng., vol. 43, no. August, p. 103168, 2021, doi: 10.1016/j.jobe.2021.103168.

[39] S. A. Khafaga, "Using Nano-SiO2 to improve the Mechanical and abrasion Properties of High-Volume Fly Ash Concrete Subjected to Elevated Temperatures," Int. J. Innov. Eng. Sci. Res., vol. 3, no. 5, pp. 2581–4591, 2019, [Online]. Available: www.ijiesr.com

[40] S. Du, Y. Ge, and X. Shi, "A targeted approach of employing nano-materials in high-volume fly ash concrete," Cem. Concr. Compos., vol. 104, no. December 2018, p. 103390, 2019, doi: 10.1016/j.cemconcomp.2019.103390.

[41] M. Adamu, B. S. Mohammed, and M. Shahir Liew, "Mechanical properties and performance of high volume fly ash roller compacted concrete containing crumb rubber and nano silica," Constr. Build. Mater., vol. 171, pp. 521–538, 2018, doi: 10.1016/j.conbuildmat.2018.03.138.

[42] M. Adamu, I. K. Umar, S. I. Haruna, Y. E. Ibrahim, H. Alanazi, and O. A. U. Uche, "A soft computing technique for predicting flexural strength of concrete containing nano-silica and calcium carbide residue," Case Stud. Constr. Mater., vol. 17, no. March, p. e01288, 2022, doi: 10.1016/j.cscm.2022.e01288.

[43] L. G. Li, J. Y. Zheng, P. L. Ng, and A. K. H. Kwan, "Synergistic cementing efficiencies of nano-silica and micro-silica in carbonation resistance and sorptivity of concrete," J. Build. Eng., vol. 33, no. August 2020, p. 101862, 2021, doi: 10.1016/j.jobe.2020.101862.

[44] R. Kancharla, V. R. Maddumala, T. V. N. Prasanna, L. Pullagura, R. R. Mukiri, and M. V. Prakash, "Flexural Behavior Performance of Reinforced Concrete Slabs Mixed with Nano- And Microsilica," J. Nanomater., vol. 2021, 2021, doi: 10.1155/2021/1754325.

[45] P. Xu, R. Shi, C. Wang, Y. Cui, and M. Zhang, "Flow Mechanism and Strength Characteristics of Textile Reinforced Concrete Mixed with Colloidal Nano-SiO2," Geofluids, vol. 2021, 2021, doi: 10.1155/2021/7089832.

[46] J. W. Park, K. H. Kim, and K. Y. Ann, "Fundamental Properties of Magnesium Phosphate Cement Mortar for Rapid Repair of Concrete," Adv. Mater. Sci. Eng., vol. 2016, 2016, doi: 10.1155/2016/7179403.

[47] J. O. Okeniyi, A. P. I. Popoola, and E. T. Okeniyi, "Cymbopogon citratus and $NaNO_2$ Behaviours in 3.5% NaCl-Immersed Steel-Reinforced Concrete: Implications for Eco-Friendly Corrosion Inhibitor Applications for Steel in Concrete," Int. J. Corros., vol. 2018, 2018, doi: 10.1155/2018/5949042.

[48] T. Wang et al., "Mechanical Properties and Shrinkage of Ultrahigh-Performance Concrete Containing Lithium Carbonate and Nano-Calcium Carbonate," Adv. Civ. Eng., vol. 2021, 2021, doi: 10.1155/2021/6646272.

[49] S. Srikanth et al., "Effect of Nano Ground Granulated Blast Furnace Slag (GGBS) Volume % on Mechanical Behaviour of High-Performance Sustainable Concrete," J. Nanomater., vol. 2022, pp. 1–5, 2022, doi: 10.1155/2022/3742194.

[50] P. Zhang, Y. N. Zhao, Q. F. Li, P. Wang, and T. H. Zhang, "Flexural toughness of steel fiber reinforced high performance concrete containing nano-SiO_2 and fly ash," Sci. World J., vol. 2014, 2014, doi: 10.1155/2014/403743.

[51] M. Adamu, B. S. Mohammed, N. Shafiq, and M. S. Liew, "Durability performance of high volume fly ash roller compacted concrete pavement containing crumb rubber and nano silica," Int. J. Pavement Eng., vol. 21, no. 12, pp. 1437–1444, 2020, doi: 10.1080/10298436.2018.1547825.

[52] Z. Zhou, M. Sofi, J. Liu, S. Li, A. Zhong, and P. Mendis, "Nano-CSH modified high volume fly ash concrete: Early-age properties and environmental impact analysis," J. Clean. Prod., vol. 286, no. xxxx, 2021, doi: 10.1016/j.jclepro.2020.124924.

[53] J. Sun, X. Shen, G. Tan, and J. E. Tanner, "Modification Effects of Nano-SiO_2 on Early Compressive Strength and Hydration Characteristics of

ISSN (online): 2581-3048
Volume 7, Issue 6, pp 31-38, June-2023
https://doi.org/10.47001/IRJIET/2023.706006

High-Volume Fly Ash Concrete," J. Mater. Civ. Eng., vol. 31, no. 6, pp. 1–12, 2019, doi: 10.1061/(asce)mt.1943-5533.0002665.

[54] S. S. Sankaranarayannan and J. R. Jagadesan, "Comparison of High Performance Fly Ash Concrete Using Nano Silica Fume on Different Mixes," Circuits Syst., vol. 07, no. 08, pp. 1259–1267, 2016, doi: 10.4236/cs.2016.78110.

AUTHORS BIOGRAPHY

Suhendro Trinugroho,
Lecturer in the Department of Civil Engineering, Faculty of Engineering, Muhammadiyah University of Surakarta, Indonesia.

Alpri Wisnuaji,
Student of Civil Engineering Department, Faculty of Engineering, Muhammadiyah University of Surakarta, Indonesia.

Citation of this Article:

Suhendro Trinugroho, Alpri Wisnuaji, "Literature Review: Application of Nano Cement in High Volume Fly Ash Concrete" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 6, pp 31-38, June 2023. Article DOI https://doi.org/10.47001/IRJIET/2023.706006

****

