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# Literature Review: Application of Nano Cement in Mortar

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***Abstract* - Literature review on Nano Cement to illustrate that the application of Nano Cement in mortar 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 as a partial replacement for cement is increasing, the higher the compressive strength used in the concrete. So that it can be concluded that the use of Nano Cement for concrete allows it to be applied or used, this is the aim of the Literature Study research. Data collection was carried out by reviewing several journals related to Nano Fly Ash (NFA) in the period between 2010-2023. Journal synthesis uses several national and international journals obtained from the Google Scholar database using the publish or perish application.**

***Keywords:*** Nano Cement, Mortar, Nano Cement Used Mortar, Compressive Strength, Durability.

## I. INTRODUCTION

Cement concrete, one of the most widely used building materials worldwide, possesses been employed extensively in the construction of bridges, roads, water conservancy projects, and other infrastructure. However, over the course of reinforced concrete's service life constructions, rust expansion, and concrete cracking will result from the corrosion of steel bars due to chloride salt erosion. The pore water in the concrete will freeze and thaw as a result of temperature variations, and the combined impact of other environmental elements can cause cracking in the concrete.(3)

Starting at the material level, research on high-performance concrete materials appropriate for hostile conditions is required to enhance the performance of reinforced concrete structures. Currently, one of the essential technological techniques utilized to increase the durability of cementitious materials is the addition of mineral admixtures.(3)

The main nano-scale admixtures employed in cement-based materials include Carbon Nanotubes, Nano-$SiO_2$, Nano-$CaCO_3$,Nano Clay, and Nano-$SiO_2$.According to this study, several nanoparticles employed to alter cement-based materials have good toughness, better compactness, improved crack resistance, and improved impermeability.(3)

The use of Nano Titanium Dioxide (NT) in cementitious materials to give architectural structures and buildings special qualities has gained more and more attention. Titanium Dioxide ($TiO_2$) may break down a variety of organic and inorganic air contaminants when exposed to ultraviolet light and heat, improving the health of people and other living things.(8)

Photocatalysis is the process of photodecomposition by light absorption, and titanium dioxide is one of the most potent photocatalysts now on the market. $TiO_2$'s"self-cleaning" ability can be widely used when mixed with cement, for example, to assist urban centers in improving their air quality. Additionally, for architectural purposes, titanium dioxide cement/concrete's white color is often desirable.(8)

Small particles having an amorphous $SiO_2$ core and a hydroxylated surface are referred to as Colloidal Silica (CS), and they are insoluble in water. The particles' sizes can be adjusted between 1 and 500 nm, making them tiny enough to avoid settling and staying floating in a fluid media. The synthesis technique allows for the control of parameters including particular surface area, size, and size distribution.(2)

The nanometer-sized CS particles make up a highly reactive siliceous material due to their high specific surface area. It has not yet been determined, however, whether the faster hydration of cement in the presence of Nano-Silica results from the latter's significant surface activity or from the former's chemical reactivity upon dissolution (pozzolanic activity).(2)

Adding Synthetic Colloidal Silica to concrete and cement mortars has recently made a contribution to the development of building materials, and the finished product exhibits superior aging features with regard to strength gain, sulfate attack, and alkali-silica reactions.(2)

Due to their exceptional mechanical qualities and distinctive geometrical traits, nanoparticles have recently received attention as a potentially advantageous replacement

 

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for conventional additives. Nanomaterials are dispersed on a much smaller scale than other materials because of their small size. Additionally, NanoFiller might be able to fill tiny gaps between the components of cement mortar.(7)

This will improve the mechanical properties of the cementitious materials as well as other qualities like workability, consistency, and water absorption by limiting the spread of microcracks inside them.(7)

The physical and chemical composition of halloysite nano clay may improve the performance of cementitious composites. Kaolin clays react with the cement during hydration, changing its characteristics. Due to dissociation, they are active as pozzolan during hydration, producing ions that lead to the creation of cementitious compounds. The dissociated alumina is thought to be used to create cementitious minerals (Calcium Aluminosilicates).(16)

Additionally, when Calcium Ions and Released Silica from the surface of Halloysite Nanoclay interact, Hydrated Calcium Silicates are created. Additionally, nanosized particles might assist in reactivating uncalcined nano clay so that it can participate in the hydration process.(16)

## II. METHOD

The research method used is a systematic literature review where the method used is a systematic way to collect, evaluate, integrate, and present findings from various research studies on questions or topics of interest. Literature review which is defined as the method applied in analyzing journals, this journal analysis confirms previous research journals and is relevant to the title used, namely research on Nano Cement in a mortar and the application of nanotechnology using a ball mill tool. Some of the journals taken were research journals conducted from 2010 to 2023. The data taken is data on the method of making Nano Cement and the results of the durability and workability of adding Nano Cement to the mortar. Furthermore, each research result is reviewed to obtain the results of the implementation method for making Nano Cement in mortar, the percentage of adding Nano as a partial replacement for cement added to mortar or concrete, and the results of durability and workability in mortar or concrete. (9)

The data source used in this review journal is data from online journals from national to international scope using the help of publish and perish applications based on Google Scholar data. The process of processing this research data is based on collecting data related to the research title, then analyzing the data in the form of the implementation method for making Nano, and comparing the results of the durability and workability of adding Nano to concrete from journals related journals. This analysis will get the results of the analysis which will be the result of the research discussion and then conclusions will be drawn from the results of the discussion.(9)

**Table 1: Literature Review Topics**

| Topics | Authors |
|---|---|
| The effect of nano-cement content to the compressive strength of mortar. | (1) Parang Sabdono, Frisky SustiawanDion Aji Fadlillah (2014) |
| Experimental study of the effect of addition of nano silica on the behaviour of cement mortars. | (2) M. Ltifi, A. Guefrech, P. Mounanga, A. Khelidjb, E (2011) |
| Study on Shrinkage Cracking Morphology of Cement Mortar with Different Nanoclay Particles under Restraint. | (3) Liu, G.; Zhang, S.; Fan, Y.; Shah, S.P (2022), |
| Effects of calcined halloysite nano-clay on the mechanical properties and microstructure of low clinker cement mortar. | (4) Allalou, S.; Kheribet, R.; Benmounah, A. 2019 |
| Effect of porosity on predicting compressive and flexural strength of cement mortar containing micro and nano-silica by ANN and GEP. | (5) Emamian, S.A.; Eskandari-Naddaf, H. 2019 |
| Effect of nanomaterials on the mechanical properties and microstructure of cement mortar under low air pressure curing. | (6) Zhang, A.; Yang, W.; Ge, Y.; Liu, P. 2020 |
| Influence of Nanoclay on the Properties and Morphology of Cement Mortar. | (7) Irshidat, M.R.; Al-Saleh, M.H (2018) |
| Multiscale pore structure analysis of nano titanium dioxide cement mortar composite. Mater. Today Commun. | (8) Shafaei, D.; Yang, S.; Berlouis, L.; Minto, J. 2020 |
| Influence of $SiO_2$, $TiO_2$ and $Fe_2O_3$ nanoparticles on the properties of fly ash blended cement mortars. | (9) Siang Ng, D.; Paul, S.C.; Anggraini, V.; Kong, S.Y.; Qureshi, T.S.; Rodriguez, C.R.; Liu, Q.; Šavija, B. 2020 |
| Influence of Titanium Dioxide Nanoparticles on the Sulfate Attack upon Ordinary Portland Cement and Slag-Blended Mortars. | (10) Qudoos, A.; Kim, H.; Ryou, J.-S. 2018 |
| Microstructure of cement mortar with nano particles. | (11) H. Li et al (2014) |
| Effect and mechanisms of nanomaterials on interface between aggregates and cement mortars. | (12) Wang, X., Dong, S., Ashour, A., Zhang, W. and Han, B., 2020. |

 

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|---|---|
| Combined effects of micro-silica and nano-silica on durability of mortar. | (13) Li, L., Zhua, J., Huanga, Z.H., Kwan, A. and Lia, L.J., 2017. |
| Experimental study of the mechanical properties and durability of self-compacting mortars with nano materials ($SiO_2$ and $TiO_2$). | (14) Rao, S., Silva, P. and De Brito, J., 2016 |
| Nanosilica and silica fume modified cement mortar used as surface protection material to enhance the impermeability. | (15) Zhang, B., Tan, H., Shen, W., Xu, G., Ma, B. and Ji, X., 2018. |
| Effect of Halloysite Nanoclay on Mechanical Properties, Thermal Behavior and Microstructure of Cement Mortars. | (16) Farzadnia, N., Ali, A. A., Demirboga, R. and Anwar, M. P (2013) |
| Properties of self-compacting mortar containing nano cement kiln dust. | (17) Kadhim, A.S., Atiyah, A.A. and Salih, S.A. (2020) |
| Evaluating the performance of high volume fly ash-blended-cement mortar individually containing nano- and ultrafine micro-magnesia | (18) Abdel-Gawwad, H.A. et al. (2021) |
| Evaluating the impact of nano-magnesium calcite waste on the performance of cement mortar in normal and sulfate-rich media | (19) Abdel-Gawwad, H.A. et al. (2019) |
| Effect of Zinc Oxide Nanoparticle on Strength of Cement Mortar | (20) Nivethitha, D. and Dharmar, S. (2016) |
| Influence of nano-silica on the leaching attack upon photocatalytic cement mortars | (21) Atta-ur-Rehman et al. (2019) |
| Thermal and mechanical properties of cement mortar composite containing recycled expanded glass aggregate and nano titanium dioxide | (22) Yousefi, A. et al. (2020) |
| Modification of Portland cement with Nano SIC | (23) Bahari, A., Berenjian, J. and Sadeghi-Nik, A. (2016) |
| Hybrid effect of carbon nanotube and nano-clay on physico-mechanical properties of cement mortar | (24) Morsy, M.S., Alsayed, S.H. and Aqel, M. (2011) |
| Behavior of blended cement mortars containing nano-Metakaolin at elevated temperatures | (25) Morsy, M.S. et al. (2012) |
| Effect of Nano-clay on Mechanical Properties and Microstructure of Ordinary Portland Cement Mortar | (26) Morsy, M.S., Alsayed, S.H. and Aqel, M. (2010) |

## III. RESULTS AND DISCUSSIONS

In the percentage of nano-added materials there are various kinds of added materials such as Silica Fume, Nano-Silicate, Nano-$SiO_2$, Nano-$CaCO_3$ Nanoclay, Calcined Halloysite Nano-Clay (CHNC), Micro Silica, Nano Silica, Nano-$TiO_2$, Nano-$Fe_2O_3$, Titanium Dioxide, Nano-Particles $Al_2O_3$, The use of nano-added materials can affect the results of the compressive strength of the mortar so that the compressive strength results of the mortar are higher than the mixture without the addition of nano-materials.

Nano Silica is an added material that is often used in the research above and from the results of this addition the compressive strength value of the mortar is higher compared to other nanomaterial additives.

From the results presented it is evident that the use of nanocement can increase the compressive strength of the mortar. The compressive strength increases because the grain size of the cement used is smaller, thus perfecting the hydration reaction that occurs.

**Table 2: Percentage of Added Material Nano Cement and Compressive Strength of Mortar**

| Research Reviewer | Percentage of Nano Cement | Percentage of Other Nano Material | Compressive Strength (28 Days) | Unit |
|---|---|---|---|---|
| (1) Parang Sabdono, Frisky SustiawanDion Aji Fadlillah (2014) | 0%, 20%, 40%, 60%, 80%, 100% | 15.76 % $SiO_2$ | 49.960, 50.932, 51.807, 56.570, 60.750, 68.493 | N/mm² |
| (2) M. Ltifi, A. Guefrech, P. Mounanga, A. Khelidjb, E (2011) | 0%, 3%, 10% | 3%, 10% Silica Amorf | 35, 32, 40 | N/mm² |
| (3) Liu, G.; Zhang, S.; Fan, Y.; Shah, S.P (2022), | 3% | - | 29.1, 31.3, 26.6, 32.5, 31.6 | N/mm² |
| (4) Allalou, S.; Kheribet, R.; Benmounah, A. 2019 | 0%, 1%, 2%, 3%, 4%, 5%, 6% | 3% Calcined Halloysite Nano-Clay (CHNC) | 42, 44, 46, 52, 55, 56, 52 | N/mm² |
| (5) Emamian, S.A.; Eskandari-Naddaf, H. 2019 | 0%, 1.4%, 2.8%, 4.2% | 0%, 4%, 9%, 13% Micro Silica (Ms) | 20, 23, 28, 30 | N/mm² |
| (6) Zhang, A.; Yang, W.; Ge, Y.; Liu, P. 2020 | 1% | 0.5% Nano-$Al_2O_3$ | 53, 47 | N/mm² |

 

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|---|---|---|---|---|
| (7) Irshidat, M.R.; Al-Saleh, M.H (2018) | 0.5%, 1%, 2% | 2% Nanoclay | 38, 39, 41 | N/mm² |
| (9) Siang Ng, D.; Paul, S.C.; Anggraini, V.; Kong, S.Y.; Qureshi, T.S.; Rodriguez, C.R.; Liu, Q.; Šavija, B. 2020 | 0%, 1%, 3%, 5% | 5% Nano-$Fe_2O_3$ (NF) | 27, 32, 37, 29 | N/mm² |
| (10) Qudoos, A.; Kim, H.; Ryou, J.-S. 2018 | 0%, 3%, 6%, 9%, 12% | 0%, 3%, 6%, 9%, 12% Nano-$TiO_2$ | 45, 48, 52, 47, 40 | N/mm² |
| (11) H. Li et al (2014) | 3%, 5%, 10% | 10% $SiO_2$ and Nano-$Fe_2O_3$ | 29.7, 33.4, 34.1, 34.8 | N/mm² |
| (12) Wang, X., Dong, S., Ashour, A., Zhang, W. and Han, B., 2020. | 1%, 2%, 3% | 3.3% Silica Fume | 6, 6.25, 5, 4.3 | N/mm² |
| (13) Li, L., Zhua, J., Huanga, Z.H., Kwan, A. and Lia, L.J., 2017. | - | 0%, 10% Micro-Silica and 0%, 1%, 2% Nano Silica | 90, 79, 6 | N/mm² |
| (14) Rao, S., Silva, P. and De Brito, J., 2016 | 0.75%, 1.5%, 3% | 0.5%, 0.75%, 1% Nano-$TiO_2$ | 88.4, 86.3, 84.2 | N/mm² |
| (15) Zhang, B., Tan, H., Shen, W., Xu, G., Ma, B. and Ji, X., 2018. | 2%, 4%, 6%, 8% | 4% Silica Fume and 1%, 2%, 3%, 4% $SiO_2$ | 62.9 | N/mm² |
| (16) Farzadnia, N., Ali, A. A., Demirboga, R. and Anwar, M. P (2013) | 1%, 2%, 3% | 5% Silica Fume | 37, 41, 40, 45 | N/mm² |
| (17) Kadhim, A.S., Atiyah, A.A. and Salih, S.A. (2020) | 0%, 1%, 2%, 3%, 4%, 5% | 85% $SiO_2$ and 2% $SO_3$ | 33, 33, 34, 35, 36, 37 | N/mm² |
| (18) Abdel-Gawwad, H.A. *et al.* (2021) | 50% | 1%, 3%, 5% N-MgO and UM-MgO | 37, 42, 44 32, 34, 36 | N/mm² |
| (19) Abdel-Gawwad, H.A. *et al.* (2019) | 0%, 0.5%, 1%, 1.5% | - | 25, 29, 34, 27 | N/mm² |
| (20) Nivethitha, D. and Dharmar, S. (2016) | 1%, 3%, 5% | - | 48.15, 50.63, 49.65 | N/mm² |
| (21) Atta-ur-Rehman *et al.* (2019) | 0.45%, 3% | 0%, 0.5%, 1%, 1.5%, 2% Nano Silica | 5.5, 6, 6.4, 7, 7.5 | N/mm² |
| (22) Yousefi, A. *et al.* (2020) | 0%, 50%, 100% | 1% Nano-$TiO_2$ | 78.06, 76.72, 26.25, 29.70, 8.20, 11.40 | N/mm² |
| (23) Bahari, A., Berenjian, J. and Sadeghi-Nik, A. (2016) | 1.25%, 2%, 3.3% | - | 40.2, 41.2, 37.8 | N/mm² |
| (24) Morsy, M.S., Alsayed, S.H. and Aqel, M. (2011) | 6% | 0%, 0.005%, 0.02%, 0.05%, 0.1% Carbon Nanotubes | 54, 57, 60, 56, 52 | N/mm² |
| (25) Morsy, M.S. *et al.* (2012) | 0%, 5%, 10%, 15% | - | 2, 33, 22, 19 | N/mm² |
| (26) Morsy, M.S., Alsayed, S.H. and Aqel, M. (2010) | 0%, 2%, 4%, 6%, 8% | - | 47.1, 47.7, 48.5, 49.9, 50.5 | N/mm² |

The smaller the cement grains used will prevent the occurrence of hadly grains which are found in cement hydration reactions in general. This will also reduce the occurrence of porosity in the mortar thereby increasing the compact density due to the use of nanocement. A more complete hydration reaction will also increase the production of CSH gel when hydration occurs, and strengthen the bond between aggregates which increases the compressive strength of the mortar.

The resistance of photocatalytic mortars to the decalcification attack was enhanced by the incorporation of nano-silica. The mortars' loss of mechanical and physical qualities caused by the leaching attack decreased as the amount of nano-silica in the mortars rose. Similar to this, after being attacked by leaching, the microstructure of mortars containing nano-silica was more stable. The synergistic effects that were produced in the mortars as a result of the inclusion of nano-silica are what caused the increase in leaching resistance. First, Nano-Silica particles are extremely small and act as the reaction's nucleus in cement hydration. Around these particles, cement hydration products are created, and pores are filled. This causes the pore structure to be improved. Second, Nano-Silica can cover the gaps and serve as filler. As part of the decalcification process, hydration products must dissolve before they may be diffused into the hostile environment outside. The diffusion of $Ca_2$+ ions and the penetration of

 

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hostile ions are both impeded by the presence of Nano-Silica because it reduces pore size and permeability. Finally, Nano Silica functions as a pozzolanic substance. It creates gel made of calcium-silicate-hydrate and consumes portlandite. According to numerous earlier researches, portlandite is the hydration product that is most susceptible to leaching attack. Due to the pozzolanic impact of the Nano-Silica, the amount of sensitive portlandite is decreased with the addition of Nano-Silica, and leaching was further decreased.

## IV. CONCLUSION

The conclusions of the literature review from the results of mortar research by researchers who have done are:

1) There are not many studies that only use nano cement, including the percentage of use of nanocement.
2) In addition, from table 2 there are many studies on the form of a mixture of nano cement in the form of a mixture of nano cement with other chemical additives.
3) Other chemical additives added to nano cement include: Amorphous Silica, Nano Silica, Micro Silica, Nano-Clay, Silica Fume, Calcined Halloysite Nano-Clay.
4) In the review that produces the highest compressive strength namely those using nano cement 0.75%, 1.5%, 3% with addition of 0.5%, 0.75%, 1% Nano-$TiO_2$ yields a compressive strength 88.4, 86.3, 84.2 MPa.
5) With this literature review, it is hoped that it will become a novelty alternative for researchers who will continue the research the topics presented.

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