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Literature Review: Application of Nano Fly Ash in Concrete

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***Abstract* - Literature review regarding Nano Fly Ash (NFA) to describe that application Nano Fly Ash (NFA) on mortar or concrete is workable. The results of its application can be an influence on durability, workability, and increasing concrete strength. From the compressive strength of concrete, the usage increases Nano Fly Ash (NFA) as a partial replacement for cement, the higher the compressive strength used in the concrete. So that it can be concluded utilization Nano Fly Ash (NFA) for concrete allows it to be applied or used, this is the aim of the Literature review research. Data collection is applied by reviewing several journals related to Nano Fly Ash (NFA) in the time span between 2010-2023. Journal synthesis uses several national and international journals obtained from the database Google Scholar by using the application publish or perish. The results of this Literature review research are: (1) The method for making Nano Fly Ash uses various tools ball mill (2) influence Nano Fly Ash (NFA) on durability, workability, and increasing concrete strength and (3) application Nano Fly Ash (NFA) on construction work in the civil world.**

Keywords: Concrete, Durability, Nano Fly Ash, Workability.

I. INTRODUCTION

Currently the demand for concrete for construction work is very large. Concrete is the most widely used manmade material in the world with the 2nd rank after water [1]. Basically the manufacture of normal concrete made of fine aggregate (sand), coarse aggregate (gravel), and cement has experienced depletion in quantity resulting in a lot of damage to the environment [2]. Concrete is a mixture of cement, fine aggregate, coarse aggregate, and water which are mixed together so that it turns into a solid mass with the presence of added ingredients or the absence of other added ingredients [3]. According to [4], to make concrete with high compressive strength, density and small pores in the concrete, it is necessary there are studies conducted to look for good quality concrete and affordable costs. Cement is the most important element of a reinforced concrete structure in which the bond between aggregate and reinforcement is enhanced by the action of pozzolans. Excessive use of cement by leaving a carbon foot print can trigger harmful effects. With this, many people are looking for alternative materials from cement [5].

The large demand for energy throughout the world as a power plant causes coal as a by-product to be needed in very large quantities. As many as 600 million tonnes of coal ash are produced annually around the world, by donating fly ash as much as 80%. Just 20% off fly ash it can be used as an additive for cement by its application to concrete [6]. For the rest can only be disposed of in landfills which in the end can only cause environmental damage.

According to [4], over the past few years, in practice fly ash. It is used as a partial replacement for cement in concrete. Based on [3], concrete with high quality can be seen from the increase in the porosity of the concrete. The nature of the porosity of concrete is influenced by the gradation of the aggregate and also the fineness of the cement grains. When viewed from the aspect of cement porosity has limitations in the fineness of cement grains. This is what makes researchers look for alternatives to the use of cement as a concrete forming material, one of which is by using Nano Fly Ash (NFA).

Materials selected Nano fly ash (NFA) due to the nature of this material has chemical properties that are almost the same as cement. Making Nano Fly Ash (NFA) comes from fly ash fresh contained in coal waste in the thermal industry and power plants which are then milled with tools ball mill to change the particle from fly ash micro to nano size. In order to reduce the pile of fly ash this, a lot of research needs to be done.

In SNI 03-6863-2002 (2002: 146) the specifications of fly ash as an ingredient for concrete mixes are mentioned in three types (Andoyo, 2006), namely: 1. Fly ash type N, is fly ash resulting from calcination of natural pozzolan for example diatomite soil, shole, tuft, and pumice. 2. Fly ash type F, is fly ash resulting from the combustion of anthracite coal at a temperature of less than 2. Anthracite-type coal at a temperature of approximately 1560°C. 3. Fly ash type C, is fly ash resulting from the combustion of lignite/coal with the carbon content of about 60%. This type of fly ash has properties such as cement with lime content above 10%. The

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content of SiO_2 and Al_2O_3 in fly ash during the hydration process can effectively make concrete denser resulting in higher strength and durability. The content contained in fly ash is the presence of SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO, NaO_2, KO_2, SO_3, and P_2O_5 [8]. Based on [9] for the chemical composition of Nano Fly Ash (NFA) which shows the presence of Al, Si, and O peaks corresponding to Mullite (Al_2O_3 SO_2) and silica (SiO_2) present in the fly ash even after the microstructured fly ash is converted to nanostructured.

Nanotechnology is a technology that transforms particles of material into very small nanometers in size, with 1 nanometer being equivalent to 10-9 meters [10]. The size of the Nano Fly Ash (NFA) material varies from 1-100 nanometers [11], while the size of ordinary fly ash is 1-100 micrometers. The comparison between Nano Fly ash (NFA) particle material and ordinary fly ash is 1:1000. According to [12] a denser and more compact concrete microstructure can be created by using nano materials, filling cavities, accelerating hydration reactions, creating a better bond between cement paste and aggregate due to its high surface area.

According to [13] Nano Fly Ash (NFA) particles have a large surface area and high reactivity compared to fresh fly ash particles. This can happen because the particles are formed from the nucleation of volatile elements or through chemical reactions. Nano Fly Ash (NFA) is proven to be able to absorb more ions and bind more strongly than larger particles, so this can reduce the fraction of adsorbed ions.

The use of X-Ray Diffraction is implemented in these journals. Based on [14] X-Ray Diffraction (XRD) is an engineering material characteristic that is important and widely applied. Apart from X-Ray Diffraction, the application of Scanning Electron Microspcopy (SEM). The definition of Scanning Electron Microscopy is an electron microscope technique that can produce detailed visual images of particles with high quality and spatial resolution.

The purpose and objective of holding this journal review is intended to find out the results of several research journals in advance to find out the application to durability, workability and strength in concrete which is increasing, a comparison of the methods used for making Nano Fly Ash (NFA) in several journals, in addition to describe the application of Nano Fly Ash (NFA) in civil engineering work which is usually used as an additive in making mortar and also making concrete in construction work. This journal review is presented as a reference in knowing how much Nano Fly ash (NFA) is used in concrete work.

II. METHOD

The research method used is 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 establishes previous research journals and is relevant to the title used, namely research on Nano Fly Ash (NFA) and the application of nano technology using a ball mill tool. Some of the journals taken were research journals carried out from 2010-2023. The data taken is data on the method of making Nano Fly Ash (NFA) and the results of the durability and workability of adding Nano Fly Ash (NFA) to concrete. Furthermore, each result of the study was reviewed again to obtain the results of the implementation method for making Nano Fly Ash (NFA), the percentage of adding Nano Fly Ash (NFA) as a partial replacement for cement that is added to mortar or concrete, and the results of durability and workability in mortar or concrete. Nano Fly Ash (NFA).

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 Fly Ash (NFA) and comparing the results of the durability and workability of adding Nano Fly Ash (NFA) 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.

Table 1: Literature Review Topics

Topics	Authors
Strength and Mechanical Properties of Nano Fly Ash Concrete	[4] (Harihanandh and Sivaraja, 2016)
Thermal stability of nano structured fly ash synthesized by high energy ball milling	[9] (Rao, Narayanaswami and Prasad, 2010)
Effect of partial replacement of cement with nano fly ash on permeable concrete: A strength study	[15] (Carmichael, Arulraj and Meyyappan, 2020)

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Studi Eksperimental Aplikasi Material Nano Fly Ash Terhadap Kuat Tekan Mortar Beton	[10] (Astuti et al., 2013)
Fabrication and characterization of nano Fly ash by planetary ball Milling	[7] (Raghavendraa et al., 2014).
Comparative Study of Nano Fly Ash Concrete and Nano Metakaolin Concrete With Normal Cement Concrete	[16] (Sithara and Daniel, 2016)
The effect of nano fly ash on properties of cement mortar	[17] (Abdul-Hamead, Othman and Hmeed, 2018)
Characterisation of ultra-fine fly ash as sustainable cementitious material for masonry construction	[18] (Krishnaraj and Ravichandran, 2021)
Comparative study on chemical and morphology properties of nano fly ash in concrete	[19] (Harihanandh, Viswanathan and Krishnaraja, 2021)
Development and characterization of coal fly ash through low-energy ball milling	[20] (Hitesh, Wattal and Lata, 2021)
Sustainable utilization of pre-treated and nano fly ash powder for the development of durable geopolymer mortars	[5] (Mohana and Leela Bharathi, 2022)

III. RESULT AND DISCUSSION

Nano Fly Ash Manufacturing Method

The results of the discussion of the journals found that there were differences in the tools used in the Literature review which were sourced from several journals, namely in the method of making Nano Fly Ash (NFA) in using a ball mill tool. There are several types of ball mills including High Energy Ball (HEB), Planetary Ball Mill (PBM), Ball Mill Grinder, type ball mill (CAPCO English) and Low-energy Ball Mill. The concept of how the tool works is the same, namely by grinding fresh fly ash samples that are micro-sized and then changed after a few hours of grinding to nano-size.

Equations in journals using X-Ray Diffraction (XRD) function as identification in the characteristics of the chemical composition contained in the fly ash sample so that it can classify the type of fly ash used in the study. Classification of fly ash is divided into class C, class F, and class N. Scanning Electron Microscopy (SEM) is then used to analyze the surface of the particles in order to obtain changes in morphology and elemental analysis of the phases observed in nano structured fly ash powder particles. Furthermore, nano sized fly ash samples will be added to the test object to see the compressive strength, tensile strength and flexural strength.

Percentage of Added Material Nano Fly Ash for Cement Substitute

Table 2: Percentage of NFA Use in Each Study

Research Reviewer	NFA percentage	Testing Application
[5] (Mohana and Leela Bharathi, 2022)	0%; 1%; 2,5%; 5%; 7,5%	Application of NFA addition testing and GHFTA (Grounded Heat-Treated Fly Ahs)
[15] (Carmichael, Arulraj and Meyyappan,2020)	0%; 10%; 20%; 30%; 40%; 50%	Application of Testing the addition of NFA in permeable concrete.
[17] (Abdul-Hamead, Othman and Hmeed, 2018)	0%; 0,25%; 0,5%; 0,75%; 1%	Application of testing the addition of NFA to mortar.
[16] (Sithara and Daniel, 2016)	20%; 30%; 40%	Application of testing the addition of NFA to concrete.
[10] (Astuti et al., 2013)	0%; 5%; 10%; 15%; 20%	Application of testing the addition of NFA to mortar.
[4] (Harihanandh and Sivaraja, 2016)	23%	Application of testing the addition of NFA to concrete.

With the difference in the addition of the percentage of Nano Fly Ash (NFA) to the test object, this makes research variations, so that it can increase the accuracy in finding the durability value that occurs in the test object. This difference is also due to differences in the function of the test in the manufacture of the test object. The percentage of adding Nano Fly Ash (NFA) based on [4] is still lacking, because it only tried at 1 percentage, namely at the 23% level, so it could not get maximum results.

Durability and Workability Results for the Addition of NFA

It was found from the researchers that the testing in several journals had different levels of maximum durability.

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This can happen due to the application in the manufacture of different test specimens, namely by making test specimens for mortar and concrete, so that the composition of the materials used is also different, then by adding the same Nano Fly Ash (NFA) content to the manufacture of the test object the test the maximum value of durability will be different. The values of compressive strength, tensile strength, and flexural strength in concrete in this study did not reach a linear function because it was stated on the test object that increasing Nano Fly Ash (NFA) would affect the reduction in cement weight [10], thus making the mortar or concrete stronger. Compressive strength, tensile strength and flexural strength decrease in value.

However, the addition of Nano Fly Ash as a cement additive shows that the structure is less porous compared to ordinary conventional concrete [16]. Workability in mixing materials, mixing materials, and pouring materials to make concrete test objects using Nano Fly Ash (NFA) is the same as working conventional concrete in general. Density in Nano Fly Ash (NFA) concrete has a high density because it has a denser pore density, so the ability to make concrete becomes easier with minimum effort because Nano Fly Ash (NFA) can accelerate hydration of cement. The denser the pore density, the higher the durability value.

IV. CONCLUSION

The conclusions that can be drawn from this Literature review are how does Nano Fly Ash (NFA) work and how does the addition of Nano Fly Ash (NFA) a cement substitute work in mortar or concrete for durability and workability. In the manufacture of Nano Fly Ash (NFA) various ball mill tools are obtained which are used to obtain nano-sized fly ash. With the addition of the percentage of Nano Fly Ash (NFA) in mortar or concrete, durability values such as compressive strength, tensile strength, and flexural strength are greater than conventional mortar or concrete without the addition of Nano Fly Ash (NFA). But it was also found that the addition of Nano Fly Ash (NFA) did not have a linear function where the addition of excess Nano Fly Ash (NFA) resulted in a decrease in the compressive strength, tensile strength, and flexural strength, this was because Nano Fly Ash (NFA) had an effect on cement reduction. So the use of the percentage of Nano Fly Ash (NFA) content as a substitute for cement in mortar or concrete can be used as a predictor of the strength value of the mortar or concrete because this can be seen from the research journals conducted, the strength value of the strength of the mortar or concrete tested by comparing the test strength of conventional mortar or conventional concrete with Nano Fly Ash (NFA) concrete. Workability in the addition of the percentage of Nano Fly Ash (NFA), namely the density of mortar or concrete Nano Fly Ash (NFA) has a high density.

This can happen because Nano Fly Ash (NFA) has a denser pore density compared to cement, so it has the ability to make mortar or concrete easier to make with minimum effort because Nano Fly Ash can accelerate the hydration of cement. The application of Nano Fly Ash (NFA) in the scope of construction is that it can be applied in the manufacture of buildings, bridges, coastal protection structures, wharves, breakwaters, lighthouses and others.

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