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Literature Review: Application of Nano Cement in Concrete

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Abstract **- Conducting a literature review on the application of nano-cement to concrete in order to find out whether the application of nano-cement can be implemented in the work of construction. The resulting implementation can be in the form of the influence of concrete compressive strength, concrete tensile strength, concrete flexural strength (durability) and workability. The data used is a collection of several journals related to nano cement between 2013 and 2023. The journals used are national and international journals. The results obtained from this review are in the form of (1) Methods for making Nano Cement, (2) use of nano cement for durability and workability, (3) Application of nano cement for work of construction.**

Keywords: Concrete, Durability, Nano-Cement, Workability.

I. INTRODUCTION

Today nanotechnology is a very important role in the field of research [1]. The term nanotechnology in general can be interpreted in the understanding, control, and restructuring of materials on the nanometer order, namely the size range less and equal to 100 nm to create materials with fundamentally new properties and functions [2]. Nanotechnology encompasses science, technology, and nanoscale expertise involving credibility, measurement, modeling and size-related changes [3]. Nanotechnology can modify the properties of construction materials, especially cement and concrete [4].

Concrete is a material made by humans that are widely used in the world [5]. Concrete is the most important material in the construction industry. Concrete is defined as the most widely used man-made material in the world of construction consisting of cement, aggregate and water which is considered a multi-scale composite ranging from nano-scale hydrates to macro-scale aggregates [2]. With the massive use of concrete, the consumption of binder and energy also increases, thus increasing the production of Portland cement, which results in environmental pollution and greenhouse gas emissions of around 7% by releasing 800 kg of CO_2 in producing 1 ton of cement. [6].

In calculations that a total weight of 4.3 billion tonnes of cement is produced worldwide each year. The production of cement in very large quantities is associated with enormous energy consumption, soaring costs, and greenhouse gas emissions to the environment [7]. Cement is a material that functions as an adhesive for stone, brick, concrete, or mortar and other building materials. due to an increase in demand in the manufacture of cement, researchers are developing alternative binders that can be cost-effective and more environmentally friendly. With the renewal of technology in cement manufacturing methods that are consistent with sustainable principles, it can be the right solution for this need [7].

The types of cement according to the Indonesian National Standard (SNI) are divided into 6 namely, (1) Portland cement (SNI 15-2049-2004), which is a hydraulic cement produced by grinding the main Portland cement slag which consists of calcium silicate which is hydraulically and ground together with additional ingredients in the form of one or more crystalline forms of calcium sulfate compounds and may be added with other additives. (2) White Portland Cement (SNI 15-0129-2004), wherein the white hydraulic cement is produced by grinding white Portland cement slag consisting of calcium silicate and grinding together with additional ingredients in the form of one or more crystalline forms of calcium compounds. sulfate. (3) Portland Pozzolan Cement (SNI 15-0302-2004), is a hydraulic cement consisting of a homogeneous mixture of Portland cement and fine pozzolan with a pozzolan content of 6% - 40% by mass of Portland pozzolan cement. (4) Composite Portland Cement (SNI 15-7064-2004), is a hydraulic binding agent resulting from grinding together slag Portland cement and gypsum with one or more inorganic materials, or the result of mixing Portland cement powder with other inorganic material powders. (5) Mixed Portland Cement (SNI 15-3500-2004), which is a hydraulic binding agent resulting from grinding together of portland cement slag and gypsum with one or more inorganic materials which are unreacted. (6) Masonry Cement (SNI 15-3758-2004), consisting of a mixture of portland cement or a mixture of hydraulic cement with materials that add plasticity together with other materials used to increase setting time, workability, water retention and durability.

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The purpose and objective of this journal review literature is to find out the results of research from previous journals to find out its application in durability and workability in nano-cement concrete, and to find out comparisons of methods for making nano-cement and in the use of cement types used in research. This research, in order to get a conclusion about the use of nano-cement in concrete in the world of construction.

II. METHOD

The research method used is the Systematic Mapping Study where the method used is a literature review method where the writing is done systematically and using predetermined steps. Literature review 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 cement and the application of nanotechnology using a ball mill. Some of the journals taken are research journals that were carried out from 2013 to 2023. The data collected is data on the implementation method for making nano-cement and the results of the durability and workability of adding nano-cement to concrete. Then each research result was reviewed again to get the results of the implementation method for making nano-cement, the percentage of adding nano-cement as a substitute for some of the cement that was put into making concrete, and the results of the durability and workability of nano-cement concrete. By taking the data sources used in this review journal, data are journals originating from online national to international scope.

The process of processing this research data is based on collecting data related to the title of the research, then analyzing data on the method of making nano cement, the effect of using nano cement on durability and workability, and the application of nano cement in the world of construction.

Table 1: Literatur Review Topic of Nano Cementin Concrete

Topic	Authors
Pengaruh Komposisi Nano Semen Pada Perilaku Beton (Effect of Nano Cement Composition on Concrete Behavior)	[8](Dewi et al., 2013)
Compressive Strength of Concrete with Nano Cement	[1](Milton and Gnanaraj., 2020)
Effect of nano cementitious composites on corrosion resistance and residual bond strength of concrete	[9](Kiran et al., 2023)
Properties of cement and concrete in presence of nanomaterials	[4](Singh et al., 2020)
Development of nano cement concrete by top-down and bottom-up nanotechnology concept	[2](Chakraborty et al., 2020)
Nanocement/poly(vinyl alcohol) composites for endodontic applications	[10](Yousefi et al., 2020)
Durability Investigation on Nano Silica and Nano Cement Based Concrete	[11](Sivakumar et al., 2016)
Optimization of multifunctional nano cement composite for self - Sensing	[12](Geetha et al., 2020)
Evaluasi Produksi Semen Nano Untuk Struktur Beton di Mesir	[13](Khalafalla et al., 2019)
Feasibility of producing nano cement in a traditional cement factory in Iraq	[7](Alyasiry et al., 2017)
Strength and permeability studies on concrete with nano-cement	[14](Carmichae et al., 2017)

III. RESULT AND DISCUSSION

From the results and discussions obtained from the above journals that the chemical properties of nano-cement containSiO_2, Al_2O_3, Fe_2O_3, CaO, SO_3, MgO, Na_2O, K_2O, Cl, P_2O_5[1].

The method for making nano cement uses different ball mill tools. The process for making nano-cement is ground with a ball grinding mill using a High Energy Ball (HEB) tool for 12 hours [1] and [14]. In another study, the Planetray Ball Mill (PBM) was used for 1 hour to produce nano particle sizes [8]. Nano cement particles produced with the top-down cement nanotechnology concept are milled using ball mills, vibration mills, Raymond bills, mixing mills or air-blow mills, stirred mills and others [2] and [9]. For the manufacture of cement which will be reduced to nano size, a Wet-Stirred Media Milling (WSMM) tool is used for 15 hours [10]. The presence of grinding on the nano-cement causes an increase in the surface area of the existing cement particles so that the surface area of the cement is higher in the hydration reaction and the rate of the hydration reaction can increase [2].

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Table 2: The percentage of addition of nano cement in every research

Authors	Cement type	Percentage of Nano Cement
[1] (Milton and Gnanaraj., 2020)	Portland Cement(OPC) kelas 53	10%, 20%, 30%, 40%, 50%
[14] (Carmichae et al., 2017)	Portland Cement (OPC) kelas 53	10%, 20%, 30%, 40%, 50%
[8](Dewi et al., 2013)	Portland Cement Gresik tipe PPC	5%, 10%, 15%, 20%
[4] (Singh et al., 2020)	Portland Cement (OPC)	1%, 2%, 4%
[9] (Kiran et al., 2023)	Portland Cement(OPC) kelas 53	5%, 10%, 15%, 20%
[11] (Sivakumar et al., 2016)	Portland Cement	1%, 2%, 3%, 4%

From the results of the difference in the addition of the percentage of nano-cement and the different types of cement used, this makes the existing research variations, which produce or increase the accuracy in finding the durabilits values you are looking for. In the studies (Milton and Gnanaraj., 2020) and (Carmichae et al., 2017) it was found that the addition of nano-cement was only up to 50%, this is because if you continue to add nano-cement it can reduce the initial and final setting time on the cement paste. compressive strength increases with the addition of the percentage of regular cement replacement to nanocement up to 50% [1] and [14]. The permeability value with the addition of nano-cement increases causing a decrease in the permeability value [14].

Based on research from (Dewi et al., 2013) it was found that in the experiment the PPC nano type Gresik cement had an initial bond that was faster than the ordinary Gresik cement / OPC, this could happen due to the particle size of the PPC type Gresik nano cement (Pozolan Portland Cement) has finer particles compared to ordinary PPC / OPC (Ordinary Portland Cement) Gresik cement. The finer the cement particles, the faster the hydration process. The finer the particles, the greater the surface area. The compressive strength of concrete with increasing nano-cement content makes the compressive strength increase. So that the percentage of 20% has not yet reached the optimum point, therefore the correct addition of nano-cement has not been obtained so that the compressive strength can be maximized. The flexural strength of concrete is achieved at a content level of 15%, this is caused by several things, including due to the weakness of the aggregate and the presence of interfascia which has a crystal structure and different porosity from mortar which is farther from the aggregate [8].

In research (Singh et al., 2020) it was found that the levels of addition given ranged from 1%, 2% and 4%. Where it was found that nano-cement accelerated hydration of cement and increased compressive strength and made concrete more durable [4]. Based on (Sivakumar et al., 2016) used the percentage of addition of nano cement as much as 1%, 2%, 3% and 4%. It was found that the addition of 1% nano cement has a high compressive strength value compared to the addition of other levels. this can happen because it is influenced by the presence of additional chemicals used such as NaCl and NaOH which are mixed so that the maximum compressive strength obtained is only 1% [11].

In the study (Kiran et al., 2023) it was found that the nanocement content at a percentage addition of 15% indicated the optimum level of compressive strength of concrete. This is due to the filler effect on concrete with fewer pores and cavities. For the water permeability test of concrete, it was found that 15% nano-cement concrete was a very suitable material for its strength and long-lasting properties. Corrosion potential in nano-cement concrete with a content of 15% shows a low corrosion potential value. With the addition of the right nanoparticles can reduce corrosion and have the potential to protect reinforcing steel. This is because higher corrosion protection is offered for specimens with low corrosion potential due to the denser matrix and lower permeability of concrete. The results showed that the effect of nano on corrosion resistance was better for reinforcing steel when compared to other specimens. By adding non-material materials to the concrete, the nanoparticles are packed tightly, filling the nanovoid gaps and reducing the pores in the concrete [9].

With the existence of this nanotechnology, especially the application of nanotechnology to nanocement, it can make technological advances in the field of civil engineering construction. Its application can be applied to the manufacture of related constructions such as buildings, bridges, piers and others.

IV. CONCLUSION

The conclusion that can be drawn from the review literature from several of the above journals taken from 2013 to 2023 is that the addition of nano-cement to the work of making concrete makes the compressive strength of concrete higher. By applying nano technology, where using a ball mill tool can change cement particles that are micro-sized into nano-sized ones. With the ball mill grinding, it was found that the chemical properties of the nano-sized cement particles were the same as those of the micro-sized cement before grinding. In concrete the durability value can be seen from the research journals above that for compressive strength and flexural strength with the addition of nano-cement it can increase the durability value with the addition of nano-cement composition which also increases compared to ordinary concrete without the addition of nano-cement. The increase in

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the value of this durability can be influenced by the level of fineness of the nano cement itself. The finer the cement nanoparticles, the greater the surface area that can cause the initial setting of the cement to be faster compared to ordinary cement and has no effect on the normal consistency of the cement. In general, it was found that the addition of nano-cement can accelerate cement hydration time, increase compressive strength and make concrete more durable. With the development of nano technology in this cement, it can be applied in the field of construction, including in the manufacture of buildings, bridges, piers and others.

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