

Research on construction simulation technology of civil building structure engineering based on artificial intelligence

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Abstract. Nanotechnology is the latest technology developed by humanity, trying to use the molecular properties of materials found in nature to create devices that solve the problems plaguing humanity and their efficiency. Man is also trying to change the meaning of molecules to nano so that a body made up of these particles has all the properties of these particles. Nanotechnology is not a new field but a new approach in all areas. A new perspective in concrete technology has been created by the use of nanoparticles in recent years. Adding silica nanoparticles to concrete mixes improves its properties and increases its strength. However, different results and reported mechanisms explain the behavior of nanoparticles in the mixture; Therefore, it took much work to generalize the results and predict the behavior of nano concretes. This article is about the construction simulation technology of civil engineering based on artificial intelligence, which deals with the effect of nanoparticles on improving concrete properties. This was demonstrated by analyzing laboratory samples in various mixture configurations and observing how silica nanoparticles affected their microstructure with scanning electron microscopy (SEM). Based on SEM measurements, silica nanoparticles have a powerful effect because of their specific surface area. Their increase and decrease must be sought in interacting with the filling and nucleation mechanism and the pozzolanic activity. Each of these mechanisms dominates at different ages of hydration and affects the microstructure and mechanical properties of concrete.

Keywords: artificial intelligence; concrete; nanoparticles; nanotechnology; silica; structure engineering

1. Introduction

Civil engineering problems are often difficult to solve with traditional methods that require enormous computation resources, but AI-based solutions can often provide viable alternatives (Adeli 2001). Several artificial intelligence applications in civil engineering are reviewed, including computational sentences, fuzzy systems, neural networks, and news systems (Lu *et al.* 2012). Since 1956, when Dartmouth College coined the term “artificial intelligence, AI,” research into artificial intelligence has boomed. The development of artificial intelligence has been based on the interaction of different disciplines, such as psychology, computer science, cybernetics, linguistics information theory, and neurophysiology (Hamet and Tremblay 2017). An intelligent computer is a branch of computer science whose research, design, and application are all concerned with artificial intelligence. Researchers are studying how some of the intelligent functions of the human brain can be mimicked and performed to develop technological products and generate relevant theories (Guan 2019).

Phase One: The Rise and Fall of Artificial Intelligence in the 1950s. Second stage: With the advent of the expert system, there was a new boom in AI research from the late 1960s to the 1970s. Third Stage: In the 1980s, artificial intelligence made tremendous strides with the development

of the fifth-generation computer (Larson *et al.* 2014). Fourth stage: As network technologies developed in the 1990s, especially international internet technology, artificial intelligence research experienced a new boom (He and Deng 2023, Jia *et al.* 2023, Li *et al.* 2023a, Su *et al.* 2023). The focus of artificial intelligence research shifted from single intelligent agents to distributed networks based on artificial intelligence as a result of the development of network technologies (Holzinger *et al.* 2019). People are exploring goal-based distributed problem-solving and multi-agent problem-solving, which has made AI more practical (Ramesh *et al.* 2004). In addition, with the launch of Hopfield 98 Multilayer Neural Network Model 7, the burgeoning artificial neural network scene has emerged with network research and applications deeply permeating all walks of life (Minsky 1961).

Behaviorism, symbolism, and connectionism are the three main theories and methods of artificial intelligence. Many hopes and dreams have been raised about AI since its advent in the 1950s (Adams 2001). In structural engineering, another branch of civil engineering, new technologies are about to transform the field (Dai *et al.* 2023, Song *et al.* 2023, Yang and Mao 2023, Ye *et al.* 2023). Thanks to advancements in computer modeling, structural engineers will play a more minor and different role (on small projects) in the future, allowing very complex structures to be fabricated with artificial intelligence without human intervention (Pollack 1995). With cloud computing, complex projects can be accomplished more quickly and with less expertise, thanks to the computers’ massive processing power. By using traditional methods

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instead of a computer, a structural engineer can now dimension steel structures in seconds instead of days (Flood and Kartam 1994).

A branch of computer science that studies, designs, and implements intelligent computers is artificial intelligence. Particles with a size range of 0.1 to 100 nanometers are studied in nanotechnology (Jin *et al.* 2023, Lau and Li 2023, Wang *et al.* 2023, Zhang *et al.* 2023b). There are a variety of applications in various fields, including civil engineering, in this field that has emerged in recent decades (Cermak 2003). Concrete and steel used to construct structures have only been invested in by enterprising investors and mega-corporations in the construction industry (Björnström *et al.* 2004). Concrete's porous structure can be improved by incorporating nano-silica, nano-iron, or particles nano-clay, for example (Tabish *et al.* 2023). A copper nanoparticle coating can be applied to the surface of metal substrates to reduce roughness and fatigue, thereby reducing structural stress (Cheng *et al.* 2023, Fu *et al.* 2023, Li *et al.* 2023b, Zhang and Huang 2023). Other problems can be solved with nanoparticles, including corrosion reduction and fatigue reduction (Land and Stephan 2012).

A nanoparticle is a particle with at least one of its most diminutive dimensions (100 nm) (Zhang *et al.* 2022, Xue *et al.* 2023a, Zhao *et al.* 2024). Given the microstructure of hydrated cement and its nanoparticles, the use of nanoparticles effectively fills the tiny pores of the cement mortar, increasing the strength and, most importantly, the durability of the concrete (Aggarwal *et al.* 2015). Therefore, the use of nano-silica as one of the nanotechnology products as a highly active artificial pozzolan in concrete has been noticed by scientists. At the same time, recent advances in building material technology have enabled colloidal nano-silica (Singh *et al.* 2013). A number of studies have been conducted on concrete containing nanoparticles, comparing nanoparticles such as nano-silica to other pozzolans such as fly ash and silica fume to study mechanical properties and durability (Zhang and Zhu 2023).

One of the most commonly used nanoparticles in concrete is nano-silica, which is also known as ultrafine colloidal silica due to its tiny particle size (1–50 nm) (Cao *et al.* 2022, Cheng *et al.* 2024, Liu *et al.* 2024). It has better properties than silica due to its smaller size (Du *et al.* 2023). The applications and advances of nanotechnology in building materials have brought about significant changes in the industry. Most advances have been made in cementitious materials (Xu *et al.* 2023b). Nanoparticles, derived from nanotechnology, have been able to influence and improve their structure by being used to create cementitious materials (Cao *et al.* 2023b, Liang *et al.* 2023, Xia *et al.* 2023). Unfortunately, despite the many studies carried out in the field of nanotechnology in various sciences, the place of this technology in the concrete industry is not well understood by building designers and contractors (He *et al.* 2023).

Concrete is the world's most famous building material as a multi-phase nanostructured material (Hou *et al.* 2013). Amorphous crystalline phases are present in cement mortar with dimensions of both nanometers and micrometers (Yang *et al.* 2022b, Cui *et al.* 2023a, Ren *et al.* 2023). It is

important to note that the properties of concrete and their failure mechanisms can be seen at various length scales (nano, micro, macro), with each scale being derived from the properties of the previous scale (more minor) (Xu *et al.* 2023a). It is a nanomaterial that forms the glue that holds concrete together, or the amorphous phase (C-S-H). Activated by local chemical reactions of intermolecular forces and interfacial diffusion in response to chemical interactions (Zhan *et al.* 2022). There are several characteristics associated with this scale, including molecular structure, surface functional groups, bond lengths, and energy levels (Gawel *et al.* 2022). Based on this scale, the crystalline and amorphous phases and their interfaces are described (Scrivener *et al.* 2015). A microscale reaction between a particle and a phase is defined by nanoscale features and processes, while a macroscale reaction is defined by incident charges and the environment (Skibsted and Snellings 2019). It is ultimately the nanoscale processes that are responsible for determining the material's technical and application properties (Tang *et al.* 2023, Zhang *et al.* 2023a, Cui *et al.* 2024).

As part of nanoscience, concrete-based materials with nano and microscopic-scale structures are measured and characterized in order to understand their impact on microscopic properties and performance by using advanced characterization methods and molecular and atomic models (Schöler *et al.* 2017). To develop new universal cementitious composites with excellent mechanical properties and the potential for increasing durability and strength, including techniques for manipulating nanoscale structures, using nano engineering and techniques for manipulating nanoscale structures (Liu *et al.* 2023b, Madelatparvar *et al.* 2023, Shen *et al.* 2023). As well as low electrical resistance and high ductility, with automatic crack control, these composites have new properties (Bentz 2014). A cement component, cement phase, aggregate, and additive can also be used to improve surface properties so that better surface interactions can be achieved (Cheung *et al.* 2011).

It has now been widely accepted that silica is the best pozzolanic material for concrete due to its high pozzolanic activity (Yang *et al.* 2022a, Cao *et al.* 2023a, Huang *et al.* 2023). A nano-silica particle, however, will have a higher specific surface area and a higher number of atoms on its surface as its size approaches the nano range (Huang *et al.* 2018). The presence of surface atoms of this size creates dangling and unsaturated bonds with a large unstable residual potential force (Dorn *et al.* 2022). Because of this, nanoparticles like nano-silica have higher surface energy, and the activity of atoms on the surface is much higher, which readily reacts with other external atoms, resulting in a much higher pozzolanic activity of nano-silica (Kong *et al.* 2012).

In light of the specific surface area of nanosilica (160 square meters per gram), this seems reasonable (Huang *et al.* 2022, Cui *et al.* 2023b, Shi *et al.* 2024). The powdered amorphous silica that makes up Nano-SiO₂ has a white appearance made from amorphous silica (Liu *et al.* 2023a). Since nano SiO₂ has such a small particle size, it has a high specific surface area, a high surface energy, excellent dispersion, strong surface adsorption, and excellent chemical

purity (Xue *et al.* 2023b). In medicine, chemistry, physics, and biology, nano silica plays an irreplaceable role because of its unique properties (Senff *et al.* 2009).

According to its hydrophilicity, nano-SiO₂ can be categorized as hydrophilic and hydrophobic (Haruehansapong *et al.* 2014). Concrete contains a large amount of hydrophilic nano-SiO₂. As a result of its hydrophilic properties, water dispersed hydrophilic nano-SiO₂ well (Choolaei *et al.* 2012). Most of the nano-SiO₂ used in the experiment has a particle size of about 15 nanometers (Omidi *et al.* 2013, Ghadiri *et al.* 2016c, Mousavi *et al.* 2017).

This article deals with the effect of silica nanoparticles on improving concrete properties, which is about artificial intelligence-based civil engineering construction simulation technology. The filling effect of silica nanoparticles has been reported to be one of the most important mechanisms responsible for the improvement of concrete mechanical properties due to their addition. Concrete can be made stronger by adding nano-silica particles to the cement paste's voids in order to improve its compressive strength. As a result of their fineness and surface adhesion, nano silica particles are found between the cement particles and fill them. As a result, cement consolidates and becomes more durable.

Emphasizing the filling role of nanoparticles, it shows that the fineness of these particles causes an increase in the temperature of the hydrogenation reaction. As a result, it also increases the speed of gaining resistance. However, despite the promising potential of nano-silica in enhancing concrete properties, there are several shortcomings and challenges that need to be addressed. One of the main challenges is achieving uniform dispersion and effective bonding of nano-silica particles within the concrete matrix. Agglomeration of nanoparticles can occur, leading to reduced effectiveness and potential weak points in the concrete structure. Furthermore, long-term durability and stability of the nano-silica concrete need to be thoroughly evaluated to ensure its performance over time. In addition, the cost-effectiveness and scalability of incorporating nano-silica into concrete production should be considered. The production and synthesis of nano-silica particles may involve complex processes and higher costs compared to traditional concrete additives. It is essential to assess the feasibility of large-scale production and the economic implications of utilizing nano-silica in construction projects.

Moreover, the potential environmental impacts and sustainability aspects of nano-silica concrete should be carefully examined. The extraction and manufacturing processes associated with nano-silica production may have environmental consequences, and the long-term effects on the ecosystem need to be studied. Additionally, the disposal and recycling of nano-silica concrete waste should be addressed to ensure minimal environmental harm.

In summary, while the incorporation of nano-silica in concrete shows promise in enhancing mechanical properties and durability, addressing the challenges related to dispersion, cost-effectiveness, environmental impacts, and long-term performance is crucial. Further research and development efforts are needed to overcome these shortcomings and fully unlock the potential of nano-silica technology in civil engineering applications.

2. Experimental

2.1 Materials and devices

The nanomaterials used in this study are silicon metal oxides in powder form with a specific surface area of 600-180 nanometers and a diameter of 20-30 nanometers, which are the product of US-Nano (Research Nanomaterials). Powdered nanoparticles have received more attention due to the frequency of production and easier use. As a result of its excellent properties, nano-silica fills and densifies cement environments with pozzolanic properties and a higher specific surface than macro-scale materials, causing greater homogeneity and strength. Hence, according to the positive but limited results reported in previous research, these nanomaterials have been selected to understand their characteristics better. The maximum size of self-compacting concrete aggregates of the upper layer and ordinary concrete was selected as 3.37 and 18 mm, respectively. Also, the modulus of elasticity of sand of self-compacting concrete and ordinary concrete equals 1.3 and 4.5, respectively. The cement used is Portland type 2, the super-lubricant used is polycarboxylic type, and the product of Fosroc company with the brand name 335 Structuro and pH 6.5, and the water used is local drinking water.

2.2 Mixing schemes

After examining different mix patterns for self-consolidating and standard concrete, the final mix pattern was selected, as shown in Table 1. After 24 hours of demolded samples, the samples were cured in water at 24°C for 28 days. Concrete (CC) was 6 cm, and the Ceylon table test based on the ASTM 1437 standard was used to determine the flowability of self-compacting concrete (SCC). Its flowability was also within the range of the standard. Cubic samples with 5 cm specimens are used for compressive strength testing, 15 cm Macbey specimens for permeability testing, and 15 x 15 x 3 cm specimens for abrasion resistance testing (Azimi *et al.* 2016, Ghadiri *et al.* 2016a, b, Shafiei *et al.* 2016, 2017).

Compressive strength samples were made with self-consolidating concrete containing nanomaterials. However, in other samples, only one centimeter of the top layer of self-consolidating concrete contained nanomaterials, and the bottom of the samples was ordinary concrete. Self-consolidating concrete floors containing silica nanomaterials in different percentages are listed in Table 2. Concrete mixes are usually formulated with nanomaterials as a percentage of cementitious materials or cement. Except for the control sample, nanomaterials replaced part of the cement in several samples of self-compacting concrete (Ehyaei *et al.* 2017, Ghadiri *et al.* 2017a, b, Shivanian *et al.* 2017).

2.3 Diffusion of nano materials

Even distribution is very influential in generating positive effects of nanomaterials in the cement matrix. The dispersion of nanomaterials can be accomplished in a

Table 1 Final mix proportions of normal and self-compacting concrete

Weight per unit volume	2320	2517
Gravel	-	863
Sand	1308	1065
Super lubricant	12	-
Limestone powder	186	-
Micro silica	78	-
Water	178	183
Concrete	567	343
Design name	SCC	CC

Table 2 Mix proportions of self-compacting concrete used in the top layer of specimens

	12	12	12
Super lubricant	12	12	12
Microsilica	78	78	78
Limestone powder	186	186	186
Sand	1308	1308	1308
Water (kg/m ³)	178	178	178
The amount of nanomaterials (kg/m ³)	5.8	16.7	29.1
The amount of nanomaterials (weight percentage of cement)	1	3	5
Types of nanomaterials	Nano	SiO ₂	
Design name	OPC	NS	MN

number of ways, divided into physical and chemical methods. Among these methods are high shear agitation, mechanical agitation, ultrasonic agitation, and surfactant application. Physical and chemical methods can also be combined, which has a better effect on transmission. The most researched super lubrication, considered a surfactant material, was used to disperse nanomaterials. The surfactant absorbed on the surface of the nanomaterial from its hydrophilic part guarantees its water solubility. Typically, the surfactant is dissolved in water, then a nanomaterial is added to this solution and added to a mixture of aggregate and other concrete materials. The simple use of a mechanical stirrer leads to rapid sedimentation of the nanoparticles in an aqueous solution. Therefore, a lubricant with a mechanical stirrer was used in this study to obtain a homogeneous and stable dispersion. The optimal percentage of super-lubricant used to get the required fluidity and efficiency in the concrete and to get the proper distribution of the nanomaterials has been introduced in the range of 0.5 to 2% by weight—cementitious materials. Therefore, a 2% Super lube was used in this study. In this part of the study, the effect of the used super lubricant on the dispersion of nanomaterials and the stability of the dispersion overtime was needed. So, the nanomaterials were put into the water once and stirred with a mechanical stirrer. The same amount of nanomaterials was added again and mixed with fluxed water, and the resulting suspensions were photographed at 0, 5, 15, 30, and 60 minutes. The mixing method is that water and super lubricant are mixed, and then nanomaterials

are added to this mixture. These three compounds are mixed for 5 minutes in a unique mixer with high speed, at the same time, the dry materials of self-compacting concrete in another mixer mixed at medium speed. After this period, water containing superplasticizer and nanomaterial was added to the dry materials and mixed for 30 minutes at medium speed. In the end, SCC concrete containing nanomaterials were poured one centimeter above the molds whose bottom layer was already filled with ordinary concrete. Have been poured and kept in the mold for 24 hours. It is essential to mention that the steps of mixing ordinary concrete were done at the same time as self-compacting concrete, and a few minutes before the completion of mixing of self-compacting concrete, ordinary concrete was poured and compacted up to one centimeter from the surface of the molds. To better connect the two layers of concrete, grooves were created on the ordinary concrete below. After 24 hours, the samples were processed outside the mold and inside the water pool at a temperature of 24 °C for 15 days, and then they were subjected to various tests (Ebrahimi *et al.* 2017, Ghadiri *et al.* 2017c, Shahabinejad *et al.* 2018, Shafiei *et al.* 2020).

2.4 Water permeability test

The permeability test has been performed according to BS EN 12390-8. Each series of samples was subjected to a water pressure of 5 bar for 72 hours in the permeability measuring device. After this period, the amount of water consumed, specified in milliliters on the device, was recorded. Then the samples are taken out of the machine and broken according to the Brazilian test (indirect tension) so that the sample is divided into two halves. The depth of water penetration into the concrete is measured and recorded in millimeters. Finally, the average data obtained from three tests of each mixture was calculated and recorded as the final result.

2.5 Wear test

The wear test was performed based on the ASTM C 944 standard. For this test, samples with a length and width of 15 cm and thickness of 3 cm were used. In such a way that first the sample is fixed on the device by a clamp, then the abrasive part of the device is brought down with a manual lever to be placed on the surface of the sample, and then the device is used to rotate the abrasive part of the device for 2 minutes. Rotate on the sample and wear the surface of the sample, which was done three consecutive times in different parts of the sample surface, and finally, the average mass lost in all three stages was recorded. During rotation, the abrasive part is compressed on the surface of the samples by the weights installed in the machine's upper part.

2.6 Compressive strength test

The compressive strength test has been performed according to ASTM C 109 standard. The samples used for this test are 5 cm cubic samples of self-compacting concrete. These samples were taken out of the mold after 24

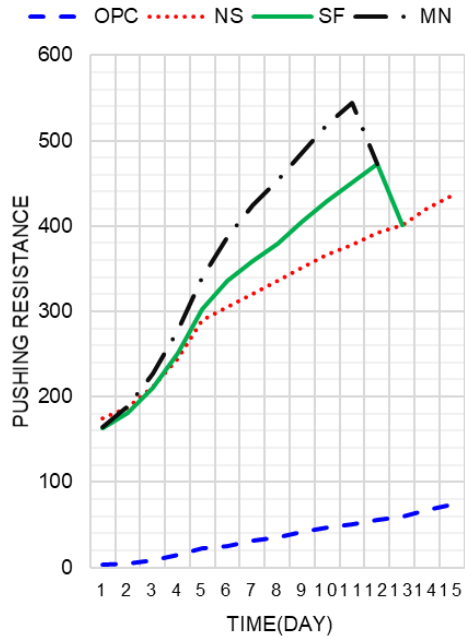


Fig. 1 Compressive strength diagram

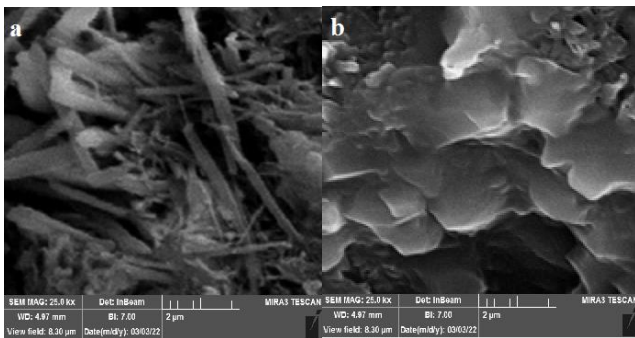


Fig. 2 Scanning electron microscope image of samples a) reference concrete (OPC) and b) concrete containing nano silica (NS)

hours and processed in water until they were 28 days old and then tested. Fig. 1 is the compressive strength of reference concretes, micro-silica and nano-silica, and the combined design. As can be seen, with the addition of a small percentage (1.5%) of nano-silica, the compressive strength of the samples increases by approximately 30% compared to the reference concrete from the microstructure of the reference concrete (OPC) samples, and the concretes containing it. This phenomenon confirms the results. Previous reports of nano-silica (NS) have been presented in this context. In the structure of the reference concrete sample, it has a heterogeneous texture, and compared to the samples containing micro-silica, the strength of the clarity samples, large crystals can be seen in it, which shows a big difference from the one containing nano-silica (at the age of 15 days), which show a significant difference in the connected needle-shaped crystals. It gives large pores in this, but with increasing age, the compressive strength of the samples can be seen even at 15 days. Containing micro-silica increases to the extent that with age, in the case of samples containing nano-silica (NS), as shown in the 15-day figure, the strength of the sample containing nano-silica

also increases 3. Concrete has a more amorphous structure, related to the compressive strength in Samples containing micro-silica, and the face is more homogeneous and integrated. As expected, nano-silica (MN) is higher than all the large crystals Ca (OH) or ettringite visible in the samples, although surprisingly, at the age of 15, the resistance is not fast, and although the porosity in the cement matrix has decreased in the micro samples Silica (SF) has a higher resistance than the composite sample, but still large pores can be identified.

2.7 Electron Microscope (SEM) Observations

Fig. 2 shows the electron microscopy (SEM) photographs of the microstructure of the reference concrete (OPC) samples and concretes containing nano-silica (NS). The structure of reference concrete sample (A) has a heterogeneous texture, clearly, large crystals can be seen in it, which are connected with needle-shaped crystals. Significant openings in this form can be seen even at 15 days. In the case of samples containing nano silica (NS), as seen in the figure, concrete has a more amorphous structure that is more homogeneously and integrally connected. Large crystals (2Ca (OH)) or ettringite cannot be observed. Although the porosity of the cement matrix has decreased, large pores can still be identified. These observations are consistent with the results obtained from the compression test.

2.8 IR spectrum of the sample

FT-IR spectra are shown in Fig. 3 for OPC and NS. A broad band at about 2935 cm^{-1} was attributed to C-stretching vibrations, and the OH stretching vibrations at 3446 cm^{-1} were related to OH stretching vibrations. C=C and C-O stretching vibrations are attributed to the bands around 1635 cm^{-1} and 1042 cm^{-1} , respectively. There were several new bands identified for the NS composite. Si-O-Si bending vibrations and Si-O-Si asymmetric stretching vibrations are attributed to the bands at 462 cm^{-1} and 1085 cm^{-1} . Also, the band at 966 cm^{-1} was assigned to stretching vibrations caused by Si-OH, and the band at 802 cm^{-1} was caused by Si-O-Si symmetric vibrations. All the results confirmed that the SiO_2 particles loaded on the OPC surface were prepared using the above method.

3. Discussion and analysis of results

It is different from developing nanoparticle concrete strength, despite many studies being conducted on nanoparticles. According to the research on concrete strength, nano-silica pozzolanic activity is responsible for the development of concrete strength. It should be noted that although micro-silica was attributed to shallow pozzolanic activity in the early ages, nano-silica exhibits high pozzolanic activity (multiple times higher than micro-silica) due to its higher purity percentage. As shown in Fig. 1, studying the process of gaining resistance in nano silica (NS) samples yields the following results. The development of nano bricks is not justified by this mechanism alone.

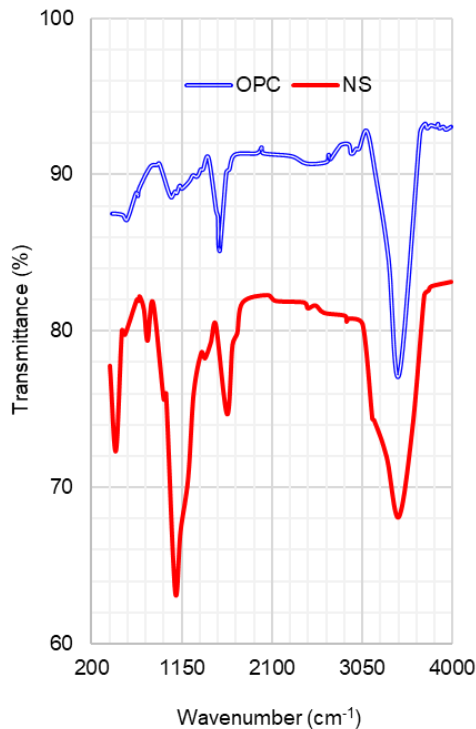


Fig. 3 IR spectrum of the sample

Early age is characterized by low micro silica activity based on research. After 15 days, only 75% of the micro-silica in the cement paste had been consumed. It can be seen from Fig. 1 that in the early ages, the amount of nano-silica in concrete significantly affected its compressive strength. As the micro-silica content of substantial increases, its initial resistance decreases, but its long-term resistance increases. Due to the characteristic activity of pozzolans in the hydration process, this slow process of gaining resistance is caused by the amorphous silicas in pozzolans that do not react directly with water but must react with the products obtained from the hydration process, leading to the formation of C-S-H gel. Consequently, as micro-silica (SF) samples show in Fig. 1, pozzolans develop more excellent resistance with increasing hydration. Nano-silica (NS) samples gain resistance rapidly at early ages (15 days). As the sample ages, it gains a higher level of resistance, exceeding the resistance of the micro-silica sample at 15 days. Moreover, it has been observed that the compressive strength of micro-silica composite samples (MN) is almost the same as that of nano-silica samples (NS) at a 7-day age. It highlights the rapid effect of the nucleation mechanism of nano-silica and the absence of pozzolanic reaction of nano-silica composites (MN), as shown by the 310 MP for nano-silica (SN) samples and 316 MP for microsilica composites (MN). Nevertheless, on 17 days, these samples reached their highest compressive strength compared than similar nano-silica samples. Similarly, the microstructure of the nano-silica samples is not homogeneous and unified, as observed in SEM photographs (Fig. 2). Thus, the texture becomes amorphous as the crystal growth is reduced. This texture still has large pores, indicating that hydration products in the concrete are distributed heterogeneously.

4. Conclusions

In this article, the impact of nano SiO_2 on the construction simulation technology of civil engineering based on artificial intelligence was briefly investigated on setting time, slump, shrinkage, durability, and mechanical properties of concrete. This review includes microstructure measurements by scanning electron microscopy (SEM). Nano- SiO_2 can shorten the setting time of concrete when used to replace part of the cement. The high activity of nano- SiO_2 promotes concrete's hydration reaction. Small particle sizes result in a large specific surface area for nano- SiO_2 . By absorbing more water molecules during concrete mixing, nano- SiO_2 absorbs a more incredible amount of unsaturated bonds, decreasing a concrete slump. The presence of nano- SiO_2 increases concrete's hydration, increasing the amount of C-S-H gel in the factual matrix, which fills the pores. Nano- SiO_2 , on the other hand, acts as a filler. By reducing the pore volume and making the concrete more compact, nano- SiO_2 can lessen the importance of the pores in concrete. Due to this, nano- SiO_2 -modified concrete is exceptionally durable. Pozzolan activity is higher in nano-silica. Due to the sufficient pozzolanic reaction, nano- SiO_2 concrete has a more significant early strength improvement effect. Nano- SiO_2 particles become smaller as curing time increases, resulting in weakened pozzolan reactions. This means that nano- SiO_2 has less of an impact on concrete strength later in the process. It also changed the content of hydration products produced during the hydration process. For example, there was a decrease in silicate content and increased hydration of calcium silicate gel. The concrete's microstructure was optimized and compacted after adding these hydration products. There was a change in macroscopical performance due to the changes in these surrounding layers.

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