THE INFLUENCE OF NANO-SILICA ON THE COMPRESSIVE STRENGTH OF PQC

K.Lokesh Reddy[1], B.Ramesh [2]

[1]M.Tech (Transportation Engineering) [2] Asst.Professor (Civil engineering Department)
Pydah College of Engineering

ABSTRACT: The application of nanotechnology in concrete provides a new dimension for improving its performance. Because of its small particle size, Nano-materials can affect the performance of concrete by changing the microstructure. This research involves the use of Nano-silica with a size of 236 nm to improve the compressive strength of concrete. Experiments were carried out by replacing cement with 0.3%, 0.6%, and 1% Nano-silica, and the fine stone was replaced by 0% to 100% stone powder with a mass fraction of 20%. The coarse aggregate and water-cement ratio remain constant.

The slump and compaction factor tests were performed on each mixture. Through the use of destructive testing, compressive strength split tensile strength, and flexural strength testing. A compression tester with a capacity of 2000kN has been used to test compressive strength of an cube with dimensions of 150mm x 150mm x 150mm within 3, 7, 14, and 28 days of curing time.

The use of stone powder can control the use of natural available resources (such as sand), which has become a very important day because, in most cities, artificial sand has been used to produce concrete. Such utilization can not only prevent negative environmental impacts but also protect nature. As the percentage of Nano silica increases, an increase in strength is observed.

INTRODUCTION:

Concrete is that the material of present and future. From buildings to factories, from bridges to airports, its extensive use in structures makes it one among the foremost studied materials within the 21st century. Thanks to the rapid increase and therefore the technological boom to satisfy these needs, there's an urgent got to improve the strength and sturdiness of concrete. Among the varied materials utilized in concrete production, cement plays a serious role thanks to its size and bonding properties. Therefore, to produce concrete with improved performance, it is necessary to properly study the hydration mechanism of cement and propose better alternative methods. Different materials called supplementary cementations materials or SCM are added to improve the performance of concrete. Some of them are fly ash, blast furnace slag, rice husk, silica fume and even bacteria. Among the various technologies used, nanotechnology seems to be a promising method to improve the performance of concrete.

THE NANOMATERIALS :-Nano-materials are materials of very small size, and their particle size is Nano-meters. These materials are very effective in shifting the performance of concrete at the Ext ordinary level due to their low size. The low size of the particles also means a larger top area. Hence the rate of pozzolana reaction is related to the available surface area; a quick reaction will achieved. Only a small amount of cement can be substitute to achieve the required result.

These Nano- materials increase the strength and permeability of concrete by compacting tiny voids and pores in the micro-structure. The use of Nano-silica in concrete mixtures has shown the result of increased concrete compressive, tensile and flexural strength. It solidifies earlier, so admixtures are usually required during mixture proportion.

Nano silica combined with cement can develop Nano-crystals of C-S-H gel after hydration. Nano-crystals are contained in the microspores of cement concrete, thus increasing the permeability and strength of concrete.

RESEARCH MOTIVATION :- Increasing the amount of cement used is essential to obtain higher compressive strength. However, cement is the lead cause of pollution. The use of Nano-materials by replacing a certain proportion of cement can lead to a change in the compressive strength of the concrete and the suppression of pollution. Since the use of a very small amount of nano-SiO_2 will greatly affect the performance of concrete, the correct study of its microstructure is essential to understand the reaction and effect of Nano-particles.

Existing documents show the use of admixtures in concrete mixtures. In this study, no admixture was used to prevent any foreign matter from affecting the concrete strength. This study is an aim to describe the effect of Nano-silica on the compressive strength of concrete by describing its nanostructure.

OBJECTIVES OF RESEARCH

The important objectives of the research are as follows:

- Contemplate the reaction of Nano-silica on the compressive strength of concrete.
- Contemplate the microstructure of hardened cement concrete.
- Explain the change in concrete properties (if any) by explaining the microstructure.

Nano SiO_2 Properties

Among all nano materials, nano silica is the most widely used material in cement and concrete with improved performance due to its Pozzolanic reactivity Pore filling effect.

There are many ways to produce nano-silica. The most commonly used method the production of nano-silica by the sol-gel method (organic or water route) at room temperature. Nano silica is also produced as a by-product of the production of metallic silicon and ferrosilicon alloy. It is collected by subsequent condensation into fine particles in a cyclone separator, it is a very fine powder composed of spherical particles or microspheres with major diameters 150 nm high specific surface area. Research on nano-scale concrete shows using nano silica can improve the accumulation of particles in concrete, and nanostructures lead to improved mechanical properties. Doped with nano silica Cement-based materials control the degradation of basic C-S-H reactions The concrete caused by the leaching of calcium in water and the prevention of water penetration and This results in improved durability. Nano silica can be obtained from natural resources in the form of crystalline minerals Silica, such as quartz, tridymite, cristobalite, and silica synthesized in the laboratory. However, Nano-silica extracted from natural resources usually contains metallic impurities, and not recommended for advanced scientific and industrial applications. Synthetic nano silica it is pure, mainly produced in the form of amorphous powder, such as silica gel, pyrolysis Silica and precipitated silica. Nano silica can be synthesized by using one of the two Main methods: top-down and bottom-up. In top-down technology, reduce the original size by using a special size reduction technique. Bottom-up technology Produce nano-silica particles from the atomic or molecular scale. The most common methods that are used are as follow:

- Through ion exchange, neutralization or electro dialysis using sodium silicate
- Through Peptized or ground by silica gel
- Through the hydrolysis and condensation of silicon compounds
- Through direct oxidation or electrolysis of silicon.

The particle size analyzer found that the average size of nano-silica was 236 nm.

Table 1: The Nano Silica Properties

TEST ITEM	TEST RESULTS
SPECIFIC SURFACE AREA (m2/g)	202
PH VALUE	4. 12
LOSS ON DRYING @ 105 DEG.C (5)	0. 47
LOSS ON IGNITION @ 1000 DEG.C (%)	0.66
SIEVE RESIDUE (5)	0. 02
TAMPED DENSITY (g/L)	44
SiO_2 CONTENT (%)	99. 88
CARBON CONTENT (%)	0. 06
CHLORIDE CONTENT (%)	0. 009
Al_2O_3	0. 005
TiO_2	0. 004
Fe_2O_3	0. 001

Fig 1: UPV Test apparatus

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 02 | Feb 2021 www.irjet.net p-ISSN: 2395-0072

Fig. 2: UPV Test of concrete specimen

Table 2: Quality of concrete based on UPV

PULSE VELOCITY	CONCRETE QUALITY
>4000 m/s	Excellent
3500-4000 m/s	Very Good
3000-3500 m/s	Satisfactory
<3000 m/s	Poor

PROPERTIES FOR FRESH CONCRETE

The performance of fresh and hardened concrete is affected by the grade of fine aggregate and coarse aggregate, respectively. According to IS 7320-1974 and IS 5515-1983, the slump cone test and compaction factor test were carried out to verify the workability of all twenty-four mixing ratios. Means, it can be seen from these results that when the substitution percentage of nano silica for cement is increased from 0% to 1%, and the substitution percentage of stone dust for fine aggregate is increased from 0% to 100%, the slump Degree and compaction factor values gradually increase. The slump value varies from 45mm to 110mm, and the compaction coefficient value varies from 0.85 to 0.93. The workability of the control concrete is extremely low (45mm).

From these results, it can be inferred that according to the grade test, 100% of natural sand is finer than stone dust. Therefore, due to the increase in surface area, the demand for water increases to achieve moderate process ability. When stone dust is used instead of sand, since the surface area is small, a smaller amount of water is required to meet sufficient workability. Generally, stone dust is essentially a glass-like material, so compared with fine aggregates, water absorption is very low.

Concrete Density:-

This research involves two materials of different densities. Replace cement with NS part with the highest specific gravity of 30%. The specific gravity is 2.2, which is lower than the specific gravity of cement. The specific gravity of stone dust is 3.52, which can replace the fine aggregate. The highest specific gravity is 100%. The density of fresh concrete ranges from 2420 kg/m3 to 3160 kg/m3. The fresh density of concrete increased by 100%, SD replaced fine aggregate, and NS increased from 0% to 30%, which was 30.6%, 26.4%, 21.1% and 22.3% higher than the control concrete respectively. It can be seen from these results that as the substitution of NS and SD increase the density of concrete decreases. The density of fresh concrete exceeds 3000 kg/m3, 100% SD is used instead of fine aggregate, and 0% to 10% of NS is used instead of cement. Due to the increase in the content of NS and SD, the content of all other mixtures is below 3000 kg/m3, and the concrete compensates for the density of the concrete. The density of ordinary concrete is in the order quantity ranges from 2200 kg/m3 to 2600 kg/m3. The density of high-density concrete ranges from 3360 kg/m3 to 3840 kg/m3. In this study, the density of concrete is higher than the density of ordinary concrete, but lower than the high density of concrete. Low-density concrete is also undesirable because it performs relatively poorly under reverse cyclic loading. Therefore, this type of concrete may be suitable for earthquake-prone areas.

Compressive Strength:- According to the mix design, the target average strength of M40 concrete is 48.25N/mm2. After 28 days of curing, the optimal compressive strength of NS 1 SD 40 has reached 59.5 N/mm2. Most mixing ratios meet the target average intensity.

Splitting Tensile and Flexural Strength:- It can be seen from the experimental results that tensile strength and bending strength behave similarly. When 1% NS is used instead of cement and 40% SD is used to replace concrete with fine aggregates, the best strength is achieved. After that, the intensity curve dropped. Mixtures with a SD content of up to 40% can increase the tensile strength of concrete. The reason for the increase in tensile strength may be the strong interface bond between SD and NS slurry. The irregular surface of SD aggregate particles is full of hydration products. As a result, they provide better bond strength and, therefore, improved tensile strength.

CONCLUSION:-

- According to the particle size distribution, the fineness modulus of CS is higher than that of fine aggregates.
- Stone Dust has a smaller surface area, so the water requirement is reduced to obtain sufficient workability.
- When the content of SD and NS in concrete increases, the slump and compaction coefficient values will also increase.
- According to the classification test, 100% natural sand is finer than SD, and as a result, due to the increase in surface area, the demand for water increases to achieve moderate concrete workability.
- The water absorption rate of stone dust is 0.13%, and the water absorption rate of sand is 1.08%. Therefore, as the content of stone dust in concrete increases, the workability of concrete is significantly improved.
- Based on the SEM image, both SD and NS have spherical particles. Therefore, due to the ball action of NS and SD, the workability of concrete is improved.
- When the amount of stone dust in concrete increases, the density of concrete increases. This happens because stone dust. However, due to the low specific gravity of nano-silica, the density of concrete is slightly reduced.
- Based on the density of concrete, it can be concluded that higher density concrete is suitable for reverse load conditions.
- In concrete using NS alone, the initial increase rate of its compressive strength has been reduced due to slow Pozzolanic action, but the strength develops in later ages.
- It can be seen from the compressive strength test results that when the curing time increases, in NS 1SD 40 concrete, 1% nano-silica and 40% stone dust are used instead, and a higher strength of 59.5N/mm2 can be obtained. .
- During the 28-day curing period, the compressive strength of all mix ratios is higher than the target average strength of M40 concrete.
- Here, we found that nano-silica helps to improve the early strength and durability of concrete.
- Based on the tensile strength of concrete, NS1SD40 mixture is suitable for pavement, runway and airport construction.
- NS 1SD40 concrete reached a higher flexural strength of 6.5 N/mm2 at 28 days, showing higher tensile strength. The use of fluted materials can increase the tensile strength of concrete.

References

1. IS:2386-1963 (Section-III). Methods of Test for aggregates for concrete Part III specific gravity, density, voids, absorption and bulking. Bureau of Indian Standards.
2. IS:383-1970. Specification for coarse aggregate and fine aggregate from natural sources for concrete. Burea of Indian Standards.
3. IS:455-1989. Portland Slag Cement- Specification. Burea of Indian Standards.
4. IS:456-2000. Plain and Reinforced concrete- code of practice (Fourth Revision). Bureau of Indian Standards.
5. Hui Li, Hui-gang Xiao, Jie Yuan and Jinping Ou. (2004). Microstructure of cement mortar with nanoparticles. Composites: Part B 35, 185-189.
6. Ji, Tao. (2005). Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO2. Cement and Concrete Research 35, 1943-1947.
7. Byung-Wan Jo, Chang-Hyun Kim, Ghi-ho Tae and Jang-Bin Park. (2007). Characteristics of cement mortar with nano-SiO2 particles. Construction and Building Materials 21, 1351-1355.
8. Nilli, M., Ehsani, A. and Shabani, K. (2009). Influence of nano SiO2 and micro silics on concrete performance. Bu-Ali Sina University Iran.
9. Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Embedded ZrO2 nanoparticles mechanical properties monitoring in cementitious composites. Journal of American Science 6(4), 86-89.
10. Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Improvement of the mechanical properties of the cementitious composites by using TiO2 nanoparticles. Journal of American Science 6(4), 98-101.
11. Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Mechanical

properties of cement mortar with Al2O3 nanoparticles. Journal of American Science 6(4), 94-97.

12. Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz and Mohamad Amra Mohd Salleh (2010). Experimental investigation of the size effects of SiO2 nano particles on the mechanical properties of binary blended concrete. Composites: Part B 41, 673-677.
13. G.Quercia and H.J.H.Brouwers (2010). Application of nanosilica(nS) in concrete mixtures. 8th fib PhD symposium in Kgs. Lyngby, Denmark.
14. M.S. Morsy, S.H. Alsayed and M. Aqel. (2010). Effect of Nano clay on mechanical properties and microstructure of Ordinary Portland Cement mortar. International Journal on Civil Engineering & Environmental Engineeering IJCEE-IJENS Vol. 10 No. 01.