



# Behaviour of Different Nanomaterials in Geopolymer Concrete

M. Manoj Kumar, S. Yuvaraj

**Abstract:** *In stock, because of the low carbon dioxide radiation, geopolymers are very important worldwide as a building material, unlike Portland cement. Today, nanotechnology is an indispensable feature in the field of building management. It has observed that several nanomaterials influence various properties of cement-based concrete. Fly ash-based geopolymer- concrete is an option for cement-based concrete, and nanoparticles change the properties of geopolymers. Nanomaterials, such as CNTs, nano-silica, and graphene, combined with gene polymer mortars, significantly improve their properties. NanoTiO<sub>2</sub>, when found, acts as a photocatalyst. Particularly nanomaterials such as nano-silver act as anti-bacterial agents. The functions of several nanomaterials have been studied and discussed to change the properties of geo-polymer concrete and mortars.*

**Keywords:** *Portland cement, Geopolymer Concrete, NaNo CaCO<sub>3</sub>, NaNo TiO<sub>2</sub>, Graphine Oxide Nanomaterials, Geopolymers,*

## I. INTRODUCTION

Next to the water, concrete is a more alternative fabric used on the surface, and you want large amounts of Ordinary Portland cement (OPC) [1]. OPC imitation now not only provides a wide variety of natural resources, limestone, and blazing but also produces about 0.8 tonnes of CO<sub>2</sub> per 1 ton of cement blur production. Cement manufacturing reaches all the people with greenhouse fuel technology, especially in CO<sub>2</sub>. By the 12 months of 2020, it required that CO<sub>2</sub> emissions reach 100% of the production peak. The Yearly global cement manufacturing demanded to reach 4,38 million in 2050, with a 5% growth over 12 months. Therefore, it is essential to decide on the more valuable, useful, and more resistant alternative Portland cement materials. Due to low carbon dioxide emissions, geopolymers are gaining international attention in the evaluation of Portland cement. The mechanism for geopolymers is a polymerization method that involves the chemical reaction of alumina silicate materials in the presence of an alkaline medium, resulting in the formation of a triangular polymer chain. Geopolymers have many blessings as a binder because they can offer excessive mechanical power, high chemical resistance to corrosion environment, low deformation and contraction, and high-temperature resistance.

Revised Manuscript Received on March 30, 2020.

\* Correspondence Author

**Mr. M. Manoj Kumar**, Research Scholar, Dept. Of Civil Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute Of Science And Technology, Chennai

**Dr. S. Yuvaraj**, Associate Professor, Dept. Of Civil Engineering, Vel Tech Rangarajan Dr Sagunthala R&D Institute Of Science And Technology, Chennai

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](http://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

**Table.1** The physical and Chemical properties of OPC:

| Chemical composition                     | Content (%) |
|--|-------------|
| CaO                                      | 59.48       |
| SiO <sub>2</sub>                         | 18.73       |
| Al <sub>2</sub> O <sub>3</sub>           | 5.12        |
| Fe <sub>2</sub> O <sub>3</sub>           | 3.45        |
| MgO                                      | 4.02        |
| SO <sub>3</sub>                          | 2.83        |
| LOI                                      | 2.51        |
| Specific gravity(g/cm <sup>3</sup> )     | 3.15        |
| Specific surface area(m <sup>2</sup> /g) | 0.39        |

The blast furnace slag, Fly-ash, cement kiln dirt, iron manufacturing slag, silica smoke, and modern and other losses, rice husk ash, methacrolein, etc., are being used for the mixture of geopolymers. Generally, there is electricity benefit while mortars filled between 40-80° C. However, one of the main restrictions associated with industrial-based geopolymer mortars is their reduced energy efficiency at room temperature curing. To overcome this complex range, which includes slugs, limes and ultra-fine fly ashes, they are provided during the geo-polymerization. Nanomaterials can be described as physical materials having at least one dimension between 1 to 150 nm (1 nm = 1e-9 meters). Nanomaterials have also been introduced in geopolymer mortars to improve habitat. Some of them are nano-silica, nano-clay, nano-linen material, nano- metakaloin and nano-X [2].

## II. TESTING PROCEDURE:

Alkaline The ratio of the intensity of change to the ratio of the material content and the proportion of ash, aggregate and water cement. For the training session, compression power of geopolymer concrete for various mixtures with nano materials and, although it is no longer an increase of nano fabric, 100 samples of fifty-five × 150 mm × 150 mm shapes were corrected. Were. All samples were tested for 7 days and 28days, once during a special exercise, for exercise sessions.

## III. TYPES OF NANO MATERIALS USED IN CONCRETE

New applications are allowed, from structural improvements to the self-cleaning residences through the fine chemical and physical properties of nano-meter scale materials. As a result, different nanomaterials were used in concrete to make it a real "smart" fabric.



# Behaviour of Different Nanomaterials in Geopolymer Concrete

## A. NANO SILICA

Silicon dioxide Nanoparticles, also known as silica or nano silica nanoparticles, are the basis of a large amount of biomedical research due to their durability, low toxicity and ability to work with a range of molecules and polymers. The nano silica particles are divided into type P and type S according to their composition. The P-type particles are characteristic of many nanopores, which have a rate of 0.61 ml / g and reflect maximum ultraviolet compared to the type S. The latter level is also relatively high. It plays an important role in increasing the compressive strength of geopolymer concrete. This is fixed quickly and, therefore, usually requires a thorough mixing. Mixed silicon dioxide nanoparticles to form nano-crystals once [3].

**Table.2 Properties of nano silica**

| Particle size(nm) | Specific surface area (m <sup>2</sup> /g) | Density (g/cm <sup>3</sup> ) | SiO <sub>2</sub> purity (%) |
|-------------------|---|------------------------------|-----------------------------|
| 15                | 250                                       | 0.05                         | 99.9                        |

### Properties of Nano silica

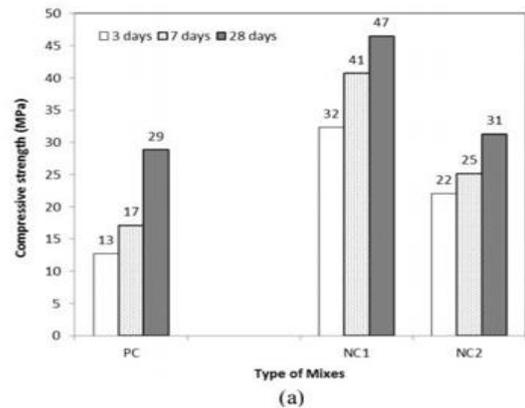
Density- 0.05 g/cm<sup>3</sup>  
 Specific gravity-2.20-2.40  
 Mean particle size-15.0nm  
 Specific surface area (m<sup>2</sup>/g) – 250  
 SiO<sub>2</sub> purity – 99.9%  
 Chemical composition of Nano Silica: Silicon-46.83%  
 Oxygen-53.33

**Table.3 Mixing proportions of cement-nano-silica paste specimens**

| Water-ti binder ratio(%) | Mixing Proportions (kg/m <sup>3</sup> ) |              |            |                              |
|--------------------------|---|--------------|------------|------------------------------|
|                          | Water                                   | Cement       | Nanosilica | AE water reducing agent      |
| OPC<br>30<br>50          | 486<br>612                              | 1619<br>1224 | -<br>-     |                              |
| OPC+NS<br>3<br>30<br>50  | 486<br>612                              | 1570<br>1187 | 49<br>37   | Binder*0.8 %<br>Binder*0.5 % |
| OPC+NS<br>6<br>30<br>50  | 486<br>612                              | 1522<br>1151 | 97<br>73   | Binder*1.6 %<br>Binder*1.0 % |

The nanoparticles (NC) particles were added to the flying ash, whose weight was 1.0, 2.0, and 3.0%, respectively. The fly ash and nano particles were first dried in a low-speed mixer for 5 minutes and then mixed for another 10 minutes at high speed until uniformity was achieved. The alkaline solution was then slowly added to a fly ash / nanoparticle mixer in a Hobart mixer, until the mixture was evenly mixed, followed by additional mixing for 10 minutes at high

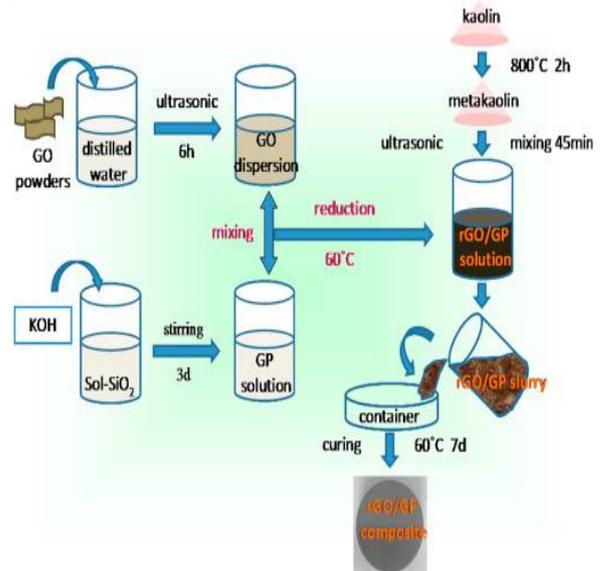
speed. As a result, the mixture was put into wooden molds. Then the wooden molds were placed on a vibration table for 2 minutes before being covered with a plastic film and fixed in the oven at 80 ° C for 24 hours before opening. The following compressive strength results were observed which is represented graphically.



**Fig. 1 Compressive strength results**

## B. Geopolymer in presence of reduced Graphene oxide

Graphene is a carbon atomized fabric that can be repeatedly incorporated into hexagons. The graphene is thin enough to hold it in two directions. Graphene's Flat Honeycomb pattern offers it many wonderful features, including being one of the strongest fabrics internationally, the lightest, most compact and one of the most visible. Graphene has unlimited potential applications in almost all companies. Graphene oxide (GO) is one of these materials: It is an unmarried atomic layer fabricated by the efficient oxidation of graphite, which is well-priced and substantial. Graphene oxide is an oxidized form of graphene, combined with oxygen-containing organisms. When it is considered to be dispersed in water, it is considered a neat technique [4].



**Fig. 2 Formal diagram of graphene oxide (GO) dispersion**

**PREPARATION:**

Uniformly dispersed graphene reinforces geopolymer compounds by reducing the position of graphene oxide (GO) in geopolymer alkaline solutions. It was found that the tensile strength of the mix increased up to certain percentage of GO and decreased on adding further. The results are depicted below graphically.

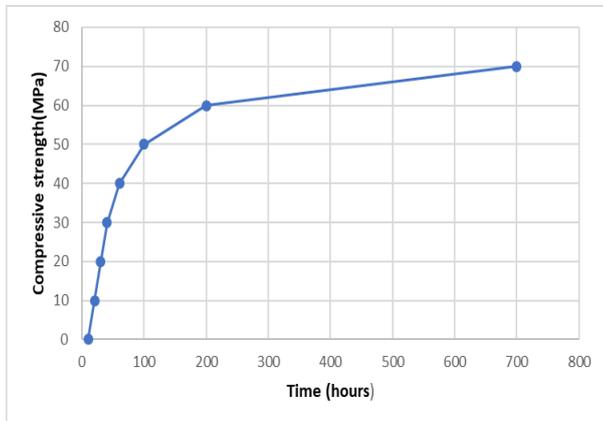


Fig.3 OPC Nano silica paste with water to binder ratio 0.3 and NS 6%

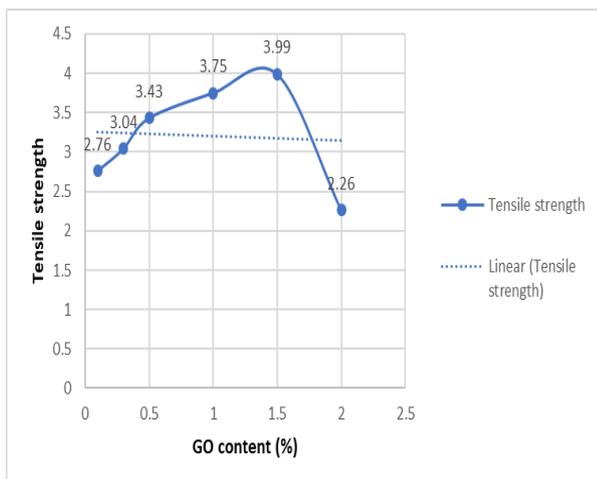


Fig.4 Tensile strength results of cement mortar specimens

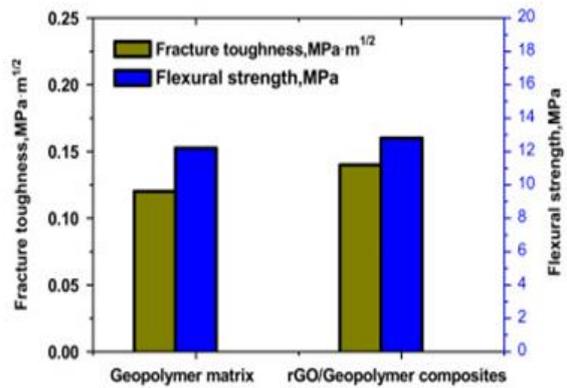


Fig.5 Results of the Fracture Toughness observed

**C. MULTI WALLED NANO TUBES:**

Carbon nanotube is a form of carbon that has a cylindrical form, the so-called nanomaterial comes from its diameter. They can be several millimetres long and can have a "layer" or wall (one wall nanotube) or more than one wall (multiple wall nanotube). Nanotubes belong to a self-contained family and exhibit impressive electrical and Specific power plants because of its efficient thermal insulation. For example, they have a Young module five times and eight Examples of metal strength (theoretically 100 examples), also 1/6 of the density. Expected benefits of carbon nanotubes are: mechanical durability and concrete cracks prevention, mechanical and thermal waste improvement in ceramics and the ability to track structural fitness in real time. Carbon nanotubes are candidates for the use of cement-based materials such as nanotechnology. They show remarkable flexibility in the GPA range and resistance to order TPa modules and own unique electronic and chemical properties [5].

Table.4 Properties and compositions of untreated MWNTs

| Types of MWNT and properties                  | M1                | M2                | M3                | M4                | M5                | M6                | M7                |
|---|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Outside Diameter (nm)                         | >50               | 20-30             | 10-20             | <8                | 8-15              | 20-40             | 30-50             |
| Length (µm)                                   | 10-20             | 10-30             | 10-30             | 10-30             | 10-30             | 10-30             | 10-20             |
| Purity (wt%)                                  | >95               | >95               | >95               | >95               | >95               | >95               | >95               |
| Ash(wt%)                                      | <1.5              | <1.5              | <1.5              | <1.5              | <1.5              | <1.5              | <1.5              |
| Specific surface area, SSA(m <sup>2</sup> /g) | >40               | >110              | >233              | >500              | >233              | >110              | >60               |
| Electrical conductivity, EC(s/cm)             | >10 <sup>-2</sup> |

**PROPERTIES OF CARBON NANOTUBES**

(a) **Strength:** Carbon nano-tubes They are by far the strongest and strongest material in terms of precision

strength and elastic modules. This strength results from the covalent SP2 bonds formed between individual carbon atoms.



**(b) Hardness:** Hardness is considered the most difficult material. In terms of high temperature and high pressure, graphite becomes a diamond. One study found a synthesis of a super-rigid material that suppresses SWNT (a wall nanotubes) at room temperature above 24 GPa. The hardness of this material was measured with nano meters of 62-15 GPa.

**(c) Thermal:** It is expected that each of the nanotubes can have excellent thermal conductors with a tube, which shows a feature known as "ballistic delivery", however, the insulation can be accurately applied to the tube immediately. Reaches the axis of the direction shows that the SWNT maintains the thermal conductivity at room temperature with an axis of about 3500 Wm-1 k.

### PREPARATION:

A total of eight compounds were prepared and tested. Eight different volumes of MWCNT, 0, 0.01, 0.02, 0.03, 0.05, 0.10, 0.20, and 0.30% were added by weight binder. The concentration is specified by C0.00, C0.01; C0.02; C0.03; C0.05; C0.10; C0.20; and C0.30 respectively. To estimate its effect on the MWCNT / cement mixture, silica smoke was added to each compound by volume bond (S10) at a volume of 10%. By weight restriction, the amount of water in all compounds was maintained at 20%. The idea of using a low proportion of water binding is to improve the dispersion of CNT by very small particles of silica smoke. When the amount of water in the cement matrix is reduced, the chance of collision between the deposited MWCNT and silica smoke particles increases. Another reason for avoiding high proportions of water bonding is that the formation of agglomerates, such as black stripes such as nanotubes, is formed in cement paste samples after mixing. Supply plasticizer (SP) varies between 0.05 and 0.8% and is weighted by weight. Table 4 shows the design of the test sample mix. To prepare the MWCNT / cement hybrid compounds, the material was mixed using a standard Hobart mixer, defined in the American Society of Test Materials (ASTM) C-305. All dry matter, including cement, silica fumes and MWCNT were mixed for 5 minutes. After 2 minutes, the water was added through a super plasticizer and mixed for a further 5 minutes at low speed. The mixing ended with an extra 5 minutes of high-speed mixing [6].

**Table.5 Properties and compositions of surface treated MWNTs**

| Types of MWNT and properties                  | M2                | M3                | M4                | M5                |
|---|-------------------|-------------------|-------------------|-------------------|
| Outside Diameter (nm)                         | 20-30             | 10-20             | <8                | 8-15              |
| Length (µm)                                   | 10-30             | 10-30             | 10-30             | 10-30             |
| Purity (wt%)                                  | >95               | >95               | >95               | >95               |
| Ash(wt%)                                      | <1.5              | <1.5              | <1.5              | <1.5              |
| Specific surface area, SSA(m <sup>2</sup> /g) | >110              | >233              | >500              | >233              |
| Electrical conductivity, EC(s/cm)             | >10 <sup>-2</sup> | >10 <sup>-2</sup> | >10 <sup>-2</sup> | >10 <sup>-2</sup> |
| COOH Content (wt%)                            | 1.23              | 2.00              | 3.86              | 2.56              |

### D. TiO2

Nano-TiO<sub>2</sub> is Due to its low cost, safety and chemical balance, cosmetics are widely used in food and various fields. Over the past two decades, studies on the promise of modification of nanoparticles for cement-based conventional materials have attracted considerable interest. Different tip these days. The investigation into the incorporation of nano-TiO<sub>2</sub> into the Cement material has been launched. Previously, it was used in white cement training to use white paint. And later it is probably the most well-known photocatalytic semi-conductor, because it has strong oxidizing capacity, so nano-TiO<sub>2</sub> gradually became the interior decoration material and outdoor production material, including wallpapers, dry mixed concrete floors, and cement mortars [8]

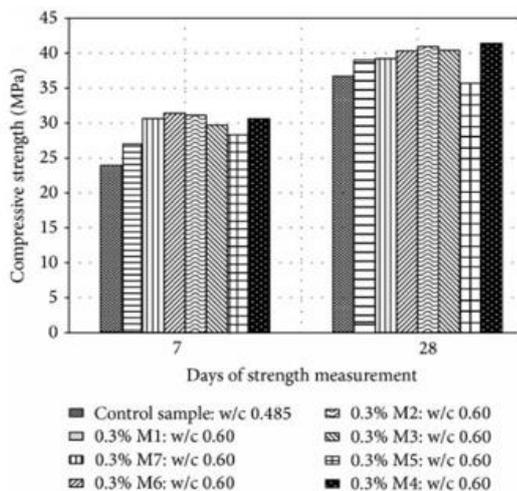
**Table. 6 Properties of TiO2 nano particles**

|                  | Diameter (nm) | Surface volume ratio (m <sup>2</sup> /g) | Purity (%) |
|------------------|---------------|--|------------|
| TiO <sub>2</sub> | 10-25         | 200                                      | 99.8       |

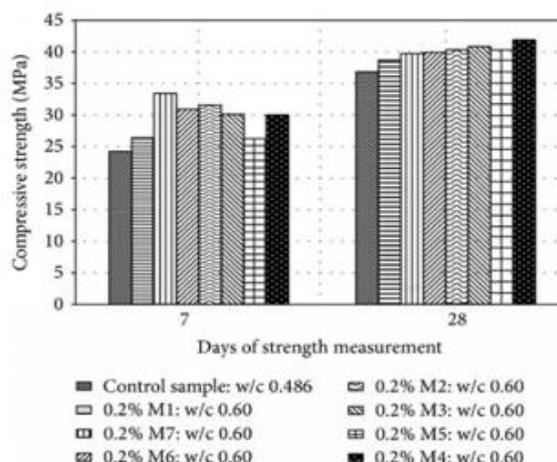
### PREPARATION:

The mixing ratio of the test sample is shown in the table below. The samples used to test the elastic strength and precision of the mortar were moulded with triple moulds of 40 mm × 40 mm × 160 mm, and 100 mm × 100 mm × 400 mm, respectively. Concrete samples that were moulded with 100 mm with. 100mm × 100mm in triple moulds. After 24 hours, they were demolished and the samples were kept in a climate chamber (20 ° C, 95% relative humidity) until they reached the test age

**IV. THE COMPRESSIVE STRENGTH FOR THE SAMPLES WERE ANALYSED AND ARE PLOTTED AS GRAPH BELOW:**



**Fig.6 Compressive strength for various 0.3% MWNT cement Mixtures with w/c 0.60**

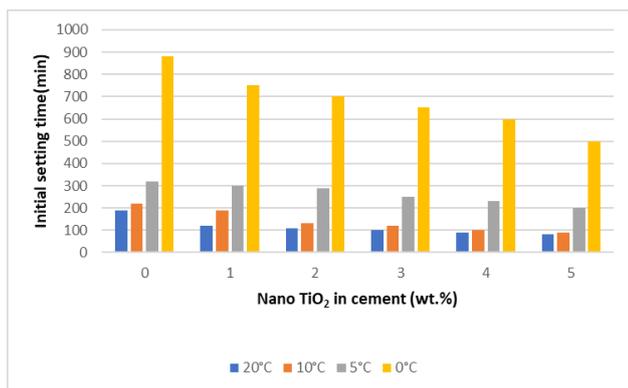


**Fig. 7 Compressive strength for various 0.2% MWNT cement Mixtures with w/c 0.60**

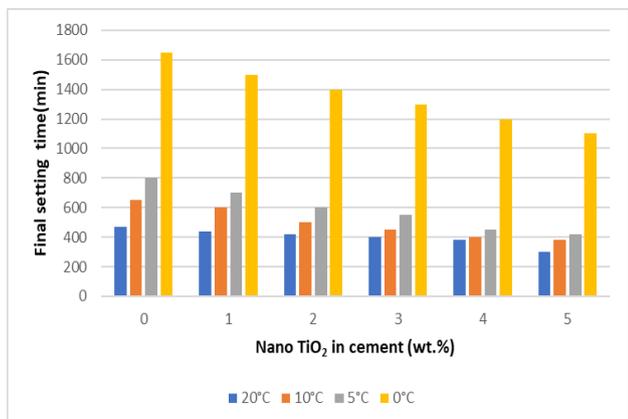
**V. RESULTS AND DISCUSSION**

**Analysis:**

The initial and final setting time were observed as below for various percentage of TiO<sub>2</sub> in cement:



**Fig.8(a) initial setting time(min) Vs Nano TiO<sub>2</sub> in Cement (wt.t)**



**(b) Final setting time(min) Vs Nano TiO<sub>2</sub> in Cement(wt.t). NANO CaCO<sub>3</sub>**

It has accurately reported, and some research has suggested that it may take advantage of the physical properties of nano CaCO<sub>3</sub> in the improvement of the cementitious system. However, it is believed that the most important strength in nanocomposite studies is to separate nanomaterials very

well in the matrix. Due to the excessive resistance of the nanoparticle flooring, nano CaCO<sub>3</sub> is overall more comfortable to form secondary waste, so that cement-based homes can be reduced. It assumed that the particle-containing nanomaterials are the answer to this question. If nano CaCO<sub>3</sub> rises above the surface of LS, then particles containing nano CaCO<sub>3</sub> / limestone (NC / LS) are ready. As can be seen in Figure 1, this method can achieve a change in skin level in LS. NC at LS level, then NC is part of LS. Therefore, the "diffusion" of NC runs through LS in cement materials. Compared to nanotechnologies, the Micron Scale LS is more accessible to achieve better dispersion due to the lower resistance of the floor. Therefore, the distribution of nano CaCO<sub>3</sub> through the NC / LS in the cement material will be significantly improved. In addition, due to the complex floor structure of nano-micron composite particles, it can significantly influence the hydration and microstructure of the cement material. Gopala Krishna et al. [7] found that the delivery of nano-CaCO<sub>3</sub> nucleation sites accelerated the process of setting and hardening the concrete to maximum performance by increasing the contact factors and improving the efficient water content for cement.

**PREPARATION:**

Nano-CaCO<sub>3</sub>/limestone Large particles arranged through inconsistent nucleation. By changing the reaction parameters together with the mixing speed, the limestone dissipation pattern is dispersed on a micron-scale after the coating is modified. The compounds containing limestone powder and saturated calcium hydroxide solution stirred at 2400 rpm for 10 minutes in a three-necked flask. Then, with the same movement, carbon dioxide gasoline is blown into a 3-neck flask. The ph cost of the reaction was changed to ph using a pH meter. When the pH rate reached 6, the response was terminated, and then carbon dioxide became a stop. The NE / LS suspension is obtained after washing with deionized water, keeping it at 100 ° C for at least 24 hours after being filtered and dried in an oven.

**Table.7 mix proportions of mortars**

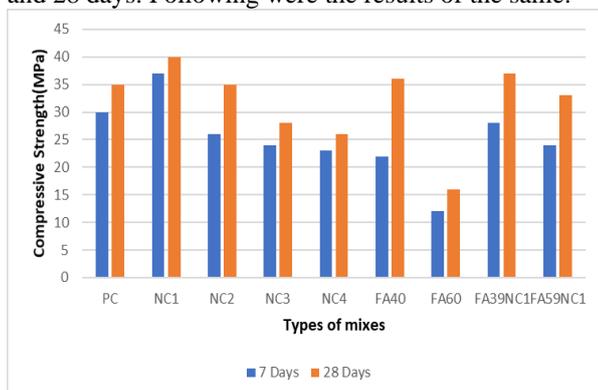
| Series | Mix designation | Cement(kg/m <sup>3</sup> ) | Class F Fly Ash | Nano CaCo <sub>3</sub> (kg/m <sup>3</sup> ) | Sand (kg/m <sup>3</sup> ) | Water (kg/m <sup>3</sup> ) |
|--------|-----------------|----------------------------|-----------------|---|---------------------------|----------------------------|
| 1      | PC              | 400                        | -               | -   | 1100                      | 160                        |
| 2      | FA40            | 240                        | 160             | -   | 1100                      | 160                        |
|        | FA50            | 200                        | 200             | -   | 1100                      | 160                        |
|        | FA60            | 160                        | 240             | -   | 1100                      | 160                        |
| 3      | NC1             | 396                        | -               | 4   | 1100                      | 160                        |
|        | NC2             | 392                        | -               | 8   | 1100                      | 160                        |
|        | NC3             | 388                        | -               | 12  | 1100                      | 160                        |
|        | NC4             | 384                        | =               | 16  | 1100                      | 160                        |
| 4      | FA39 NCI        | 240                        | 156             | 4   | 1100                      | 160                        |
|        | FA59 NCI        | 160                        | 236             | 4   | 1100                      | 160                        |

**Table.8 mix proportions of Concretes**

| Series | Mix designation | Cement(kg/m <sup>3</sup> ) | Class F Fly Ash | Nano CaCo <sub>3</sub> (kg/m <sup>3</sup> ) | Sand (kg/m <sup>3</sup> ) | Coarse Aggregate (kg/m <sup>3</sup> ) | Water (kg/m <sup>3</sup> ) |
|--------|-----------------|----------------------------|-----------------|---|---------------------------|---------------------------------------|----------------------------|
| 1      | PC              | 400                        | -               | -   | 684                       | 1184                                  | 163                        |
| 2      | FA40            | 240                        | 160             | -   | 684                       | 1184                                  | 163                        |
|        | FA60            | 160                        | 240             | -   | 684                       | 1184                                  | 163                        |
| 3      | NC1             | 396                        | -               | 4   | 684                       | 1184                                  | 163                        |
|        | NC2             | 384                        | -               | 8   | 684                       | 1184                                  | 163                        |
| 4      | FA39 NCI        | 240                        | 156             | 4   | 684                       | 1184                                  | 163                        |
|        | FA59 NCI        | 160                        | 236             | 4   | 684                       | 1184                                  | 163                        |

### ANALYSIS OF COMPRESSIVE STRENGTH:

The effect of compressive strength on cement mortar due to the occurrence of Nano CaCo<sub>3</sub> were observed for 7 and 28 days. Following were the results of the same:



**Fig. 9 Nano CaCo<sub>3</sub> observed for 7 and 28 days**

### VI. CONCLUSION

- Compressive strength for Various 0.3% , MWNT cement Mixtures with w/o 0.60 were found
- Compressive strength for Various 0.2% , MWNT cement Mixtures with w/o 0.60 were found
- initial and final setting time were observed for Nano TiO<sub>2</sub>
- Compressive strength properties of Nano CaCo<sub>3</sub> was observed for 7 and 28 days

With analysis we got below table with results

**RESULTS:**

|                      | NANO SILICA  | MULTI WALLE D NANOTUBE     | NANO CaCO3      | GRAPHINE OXIDE             | NANO TiO2 |
|----------------------|--------------|----------------------------|-----------------|----------------------------|-----------|
| COMPRESSIVE STRENGTH | Excellent    | Considerably OK            | Considerably OK | NO SIGNIFICANT IMPROVEMENT | VERY GOOD |
| FLEXURAL STRENGTH    | POOR RESULTS | NO SIGNIFICANT IMPROVEMENT | CONSIDERABLY OK | NO SIGNIFICANT IMPROVEMENT | EXCELLENT |
| TENSILE STRENGTH     | POOR RESULTS | NO SIGNIFICANT IMPROVEMENT | CONSIDERABLY OK | EXCELLENT                  | GOOD      |

**OVERALL INFERENCE:**

COMPRESSIVE STRENGTH – NANO SILICA BEST  
 FLEXURAL STRENGTH – NANO TiO2  
 TENSILE STRENGTH – NANO GO  
 OVERALL – NANO TiO2 HAS an AVERAGE POSITIVE RESULT IN ALL THREE TESTS.

**REFERENCES**

1. B D. Raijiwala, Patil H. S. 2010, “Geopolymer concrete A green concrete” pp.202-206.
2. S. Pal, S. Mandal, 2011, “Different thermal activation effect on fly ash based geopolymer concrete”, pp.23—25.
3. Vijayalakshmi M, Chiranjeevi K,2017,” A Review on Performance of Fly-Ash based Geopolymer Concrete Using Nano Expertise”.
4. F Shaikh, Supit, S, P.K., 2014, “A study on the effect of nano silica on compressive strength of high-volume fly ash mortars and concretes”, pp.433—442.
5. SofiYasir, 2015,” Study of Properties of Fly Ash Based Geopolymer Concrete “.
6. Praveen Kumar T.R., Vijayalakshmi M.M.,2019” Strength and durability performance of TiO<sub>2</sub> nanoparticles and cement concrete mixed with rice husk, building and building materials”, pp.343-351
7. Gopala Krishna Sastry K.V.S.,2017, “Effects of Nano Silica Strengths of Geo polymer Concrete Cured at Ambient Temperature”.
8. B.V Rangan, 2014, “Geo polymer concrete for environmental protection”, pp50-59.
9. Vijayalakshmi M.M., 2015, Effect of Nano particles on the properties of concrete”, pp 50-55, 2015.