International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN (Online): 2350-0557, Volume-9, Issue-6, December 2022
https://doi.org/10.55524/ijirem.2022.9.6.23
Article ID IJIR-1303, Pages 130-136
www.ijirem.org

# Effect on Workability and Compressive Strength of M40 Grade of Concrete by Partial Replacement of Cement by Nano Tio2

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**ABSTRACT-** TiO2 is one of the most often used pigment ingredients in paints due to its many benefits. TiO2 can be used as a filler material in concrete to fill in cracks, voids, fissures, bleeding channels, and other gaps, hence increasing the concrete's strength. The goal of the current work is to examine how well M40 grade high strength concrete performs when nanomaterials are used. This has been done by partially substituting nano titanium dioxide (tio2) for cement (varying from 0.5% to 2%). By performing the slump cone test and the compaction factor test, it was possible to compare the workability of M40 grade concrete with and without the addition of nano tio2. Finally, compression, split tensile, and flexural tests have been used to assess the strength properties of both types of concrete.

**KEYWORDS:** Ultraviolet radiation, NanoTio2, and High Strength Concrete

## I. INTRODUCTION

One of the key components of concrete, cement serves as a binding agent. When water is added to cement, a calcium silicate hydrated gel with a porous character is created as a result of the hydration process. However, too much water will result in unfavorable capillary cavities. A higher water cement ratio will result in wider capillary cavities, whereas a lower water cement ratio will result in cement particles that are closer together.

It is well knowledge that concrete is a porous, heterogeneous substance with many pores of various sizes and forms. The pore structure of concrete affects its physical characteristics. The pore structure of concrete affects a number of significant characteristics, including strength and permeability, directly or indirectly. It is generally acknowledged that one of concrete's most significant features is its pore structure, which has a significant impact on both its durability and mechanical qualities.

Since concrete is the most useful material in the building business, its quality must be improved. Nanoparticles used to create concrete characteristics.

a huge improvement over traditional concrete. It is clear from the literature that incorporating nanotechnology Based on the idea that components in cement concrete will improve strength, two concrete classes from table 2 of IS 456: 2000 were chosen. For the current study project, M40 grades from the standard strength category and M60 grades from the high strength category were selected. By substituting Nano Titanium Dioxide ranging from 0.5% to 2% for cement, an experiment is conducted to examine the effects on M40 grade and M60 grade concretes. The qualities of M40 and M60 grade concretes, both with and without nano titanium dioxide added, are examined in both their fresh and hardened states.

## II. LITERATURE REVIEW

Jay Sorathiya and Dr. Siddharth Shah (2017) examined how the addition of nano titanium dioxide (TiO2) affected the compressive strength of cementitious concrete. When compared to the weight of cement, titanium dioxide is substituted in various amounts, including 0.5%, 0.75%, 1%, 1.25%, and 1.5%. The workability and strength characteristics of concrete of grade M20 were investigated. They came to the conclusion that an increase in titanium dioxide concentration causes a decrease in concrete's workability. At 7 and 28 days, concrete's maximum compressive strength was noted with a 1% replacement of TiO2. Concrete's compressive strength is reduced by TiO2 content increases of greater than 1%.

An experimental investigation on the behavior of nanoconcrete was proposed by Rahini and Kannayiramoorthi (2017). in which nano titanium dioxide is used in place of cement. For M45 and M50 grade concrete, replacement is done in various percentages, such as 0.5%, 1%, and 1.5%. For 7 and 28 days, the samples are cast and allowed to cure. Compressive, flexural, and split tensile tests were performed in this study. They came to the conclusion that titanium dioxide-containing concrete is stronger than regular concrete.

A research on the dispersion properties and flexural behavior of concrete utilizing nano titanium dioxide was proposed by Aravind R and Devasena M (2016). X-ray Diffraction testing is used in this work to examine the dispersion properties of Nano TiO2.TiO2 is used to substitute cement in concrete at various ratios, such as 0.5%, 1%, and 1.5%, to study the mechanical characteristics of the material. They came to the conclusion that 1% TiO2 substitution increased compressive strength by 15% in comparison to ordinary concrete, but that 0.5% $TiO_2$ replacement decreased compressive strength by 26%. When divided tensile strength is present

Strength improves by 9% for 1% $TiO_2$, while strength reduces by 3% for each additional 0.5% $TiO_2$. A research on the mechanical characteristics of high strength concrete utilizing nanosilica was proposed by Mohammad Mufasshir alam Shah and E. Balaji (2016). The cement is changed.

K. Brahmani and D. Chandramouli (2016) presented a research employing nanoparticles to examine the properties of concrete. For M20 grade concrete, $SiO_2$ and $TiO_2$ are substituted for cement in a variety of ratios, including 0.1%, 0.125%, 0.25%, 0.5%, 0.75%, and 1%. They came to the conclusion that for $SiO_2$, concrete's compressive strength rises for 7 days and 28 days up to 0.75% and falls for additional increases in 0.25% by 14% for 7 days and 30% for 28 days. Compressive strength is unchanged for $TiO_2$ up to 0.25% $TiO_2$, and when the proportion of $TiO_2$ increases, compressive strength steadily rises to 1%.

A study on the impact of zinc oxide nanoparticle on the tensile strength and durability of cement mortar was proposed by D. Nivethitha and S. Darmar (2016). Nano Zinc Oxide is used in this cement in various amounts, including 1%, 3%, and 5%. To replace 3% of ZNO for a cement mortar ratio of 1:1, compressive strength improves by 21%, and a subsequent 1.5% increase causes compressive strength to decline by 6%. For a cement mortar ratio of 1:2, compressive strength improves by 13% and further increases in 1.5% replacement compressive strength lowers by Dr. N. Balasundaram and Dr. R. Sakthivel (2016) suggested a study on the behavior of nanoconcrete. When different percentages of Nano silica, such as 2.5%, 3%, and 3.5%, are used to replace cement in concrete of the M25 grade. When 3% Nano silica is used in place of cement, the resulting concrete is stronger and less porous than control concrete. The different qualities of concrete made with nano-silica diminish as the percentage of nano-silica increases.They came to the conclusion that using Nano silica in place of some of the cement might increase strength and permeability resistance.

Experimental study on the strength characteristics of nano alumina and GGBS on concrete was proposed by U. Karthikeya Rao and G. Senthil Kumar (2016). It was discovered that 50% was the ideal replacement rate for GGBS. Nano Alumina particles with an average diameter of 15 nm were employed in cement in various amounts, including 0.5%, 1.0%, 1.5%, and 2.0%. Compressive strength is up to 26% higher in the GGBS and 1.5% Nano Alumina mixture than in conventional concrete. Strength reduces further when Nano Alumina content rises.

Using nanomaterials, Soundarya, Sowmya, and Sujithra.E. (2015) offer an overview of developments in concrete. They offered many kinds of nanomaterials that may be employed in concrete and their benefits. Pores may be filled with nanoparticles more efficiently, increasing the material's overall strength and longevity. A new generation of cement composites may be created using nanoparticles.

Rui Zhang, Xin Cheng, Pengkun Hou, and Zhengmao Ye (2015)-The hydration of cement is accelerated by the seeding action of nano-$TiO_2$, which ultimately results in a more compact structure of the hardened paste. It is inferred that the threshold capillary pore size of the nano-$TiO_2$ added cement paste that is filled with water in an equilibrium state of the evaporation and condensation of water vapor in the pore system of cement-based materials at a specific ambient relative humidity larger than that of the control sample, meaning that larger capillary holes in the sample with nano-$TiO_2$ added should be filled with water. Due to its capacity for pore refinement and the impacts of hydration acceleration, nano-$TiO_2$ boosts the compressive strength of cementitious material. Cement-based materials with nano-$TiO_2$ addition have less drying shrinkage because of the reduced water loss caused by its effects on pore refinement and paste hydrophilicity.

A research on the impact of nano silica on the characteristics of concrete in contrast to micro silica was proposed by J. Esmaeili and K. Andalibi (2013). The best amount of micro silica to consume, according to experiments on various ratios, is 15%. However, it is stated that utilizing nano silica in addition to micro silica increases concrete's compressive strength even more. In comparison to control specimens, the combinations of 15% micro silica and 3% nano silica had a 67.5% higher compressive strength. and a reduction in concrete's permeability. They came to the conclusion that adding nano-silica particles to concrete structures will enhance the mechanical qualities and endurance of the concrete while also increasing the stability and uniformity of the hydration products.

The pore structure and chloride permeability of concrete for pavement including nano-particles ($TiO_2$ and $SiO_2$) were experimentally evaluated by Mao-hua Zhang (2011) and compared to those of plain concrete, concrete containing polypropylene (PP) fibers, and concrete having both nano-$TiO_2$ and PP fibers. The use of nanoparticles improved the concrete's resistance to chloride penetration and refined the pore structure. The improved scope of pore structure and increased scope of resistance toAs the amount of nanoparticles decreases, the chloride penetration of concrete increases. Concrete containing nano-$TiO_2$ has better pore structure and is more resistant to chloride penetration than concrete having the same quantity of nano-$SiO_2$. They discovered a hyperbolic link between concrete's compressive strength and chloride permeability.

A. Fujishima, (2008) A thorough examination of the basic processes of photocatalysis has been done. The fundamental idea is that when $TiO_2$ is exposed to ultraviolet light, it may absorb photon energy equivalent to or more than its band gap, which encourages electrons to move from the valence band to the conduction band. In the valency band, the activation of electrons creates "holes" that, depending on the surrounding circumstances, might quickly recombine to start redox processes. When water is heated, a number of radicals, including OH, $HO_2$, $O_2$, and O, can form around the active $TiO_2$, there is vapour and oxygen. They may also interact with molecules that are absorbed onto the $TiO_2$ surface, degrading those compounds in the process. Jie Yuan, Jinping Ou, Hui Li, and Hui-gang Xiao (2004) the difference in microstructures between the plain cement mortar and the cement mortar combined with nanoparticles revealed that the hydrates' $CaOH_2$ was decreased and the pores were filled with nano-$Fe_2O_3$ and nano-$SiO_2$. These methods provided an explanation for the superior mechanical properties of cement mortars containing nanoparticles. The strength of cement mortars enhanced by nanoparticles has significantly increased. It is also possible to forecast that nanoparticles will have a greater strengthening impact improved in concrete as a result of the nanoparticles' improvement of the cement paste as well as the paste-paste interface

## III. USAGE OF NANO MATERIALS IN CIVIL ENGINEERING

- Steel cables in suspension and cable-stayed bridges are being replaced with significantly stronger carbon nanotubes.
- Adding nanofibers of resistant carbon to concrete roadways in icy regions.
- Adding nano titanium dioxide to concrete to create photocatalytic concrete.
- The production of thick cement composite materials using nano-sized silica.
- The use of nanoclays to make concrete more malleable and flowable.
- Applying nano titanium dioxide to civil constructions might enhance urban air quality.

## IV. METHODOLOGY

This section gives details on the various materials' qualities that were utilized to create the study's concrete sample.
The following components were utilized in this experiment to create nanoconcrete by partially substituting nanotitanium dioxide for cement:

- Cement (grade 53 OPC)
- Aluminum Oxide
- Aggregates
- Coarse aggregate, 20 mm aggregate, 10 mm aggregate, fine aggregate, and vice versa
- Water

No. 5 Super Plasticizer

### *A. Cement*

One of the key components of concrete is cement, which, when combined with water, serves as a binding agent. The chemical interaction between cement and water results in the formation of calcium silicate hydrate gel. The C-S-H gel structure has pores that will be filled with part of the water that has been added to the cement. Over time, water that had collected in the pores evaporates, leaving the hole's empty.
Ordinary Portland cement (OPC) of grade 53 is used throughout the project to minimize the size of the pores, and it is maintained in airtight containers to protect it from humidity, monsoon moisture, and other environmental factors. According to IS, the cement is evaluated for physical requirements: 12269- 1987. The cement is limited to OPC 53 Grade Cement Physical Characteristics.

### *B. Nano Titanium Dioxide (Tio2)*

Titanium oxides that are produced naturally, insoluble in water, and non-flammable The creation of photocatalytic concrete by including titanium dioxide.

Table 1: Physical Properties of TiO2

| S.No. | Property | | Test Results |
|---|---|---|---|
| 1 | Normal Consistency | | 32% |
| 2. | Setting time | Initial(Minutes) | 130 |
| | | Final(Minutes) | 270 |
| 3. | Specific Gravity | | 3.15 |
| 4. | Compressive strength of cement mortar | 3(Days) | 28.1 MPa |
| | | 7(Days) | 44.6 MPa |
| | | 28(Days) | 57.3 MPa |
| 5. | Specific Surface area | | 320 $m^2$/Kg |

- Aggregate
- Fine aggregate

The river sand that confirmed to Zone II as per IS 383-1970 after passing through a 4.75 mm sieve and being held on a 600 m sieve was employed as the fine aggregate in the current investigation. There are no biological contaminants, clay, or silt in the sand. According to IS: 2386-1963, the aggregate's physical specifications, including gradation, fineness modulus, specific gravity, and bulk density, were examined.

Table 2: properties of fine aggregate

| S.NO | Properties | Test Results |
|---|---|---|
| 1. | Specific gravity | 2.58 |
| 2. | Bulk density ($kg/m^3$) | 1620(Loose state)<br>1750(dense state) |
| 3. | Fineness Modulus | 2.74 |
| 4. | Zone | II |

Table 3: Sieve analysis of fine aggregate

| S.No | I.S. Sieve | Weight retained (gm) | Percentage weight retained | Cumulative percentage retained | Percentage passing |
|---|---|---|---|---|---|
| 1. | 40mm | 0 | 0 | 0 | 100 |
| 2. | 20mm | 0 | 0 | 0 | 100 |
| 3. | 10mm | 0 | 0 | 0 | 100 |
| 4. | 4.75mm | 21 | 2.10 | 2.10 | 97.90 |
| 5. | 2.36mm | 65 | 6.50 | 8.60 | 91.40 |
| 6. | 1.18mm | 180 | 18.00 | 26.6 | 73.94 |
| 7. | 600µ | 278 | 27.80 | 54.4 | 45.96 |
| 8. | 300µ | 280 | 28.00 | 82.4 | 17.96 |
| 9. | 150µ | 176 | 17.6 | 100.00 | 0 |
| | | Total : | | 274.10 | |

Fineness Modulus = 274.10/100=2.74

### *C. Coarse Aggregate*

Crushed coarse aggregates of sizes 20 mm and 10 mm are obtained and used throughout the inquiry from the nearby crushing facilities. The aggregate must be of a consistent quality in terms of shape and grading, and it must be devoid of pollutants like dust, clay, and organic matter, among others. The mass of 20 mm aggregate is used as 67% of the overall mass of coarse aggregates and the bulk of 10 mm aggregate as 33%. According to IS: 2386-1963 and IS: 383-1970, the aggregate is tested for its physical specifications, including gradation, fineness modulus, specific gravity, and bulk density, among others.

Table 4: Properties of 20mm coarse aggregate

| S.No | Property | Test Results |
|---|---|---|
| 1. | Bulk density(kg/m$^3$) | 1400(loose state) |
| 2. | Specific gravity(G) | 2.72 |
| 3. | Fineness modulus | 7.17 |

Table 5: Sieve analysis for 20mm coarse aggregate

| S.No | I.S. Sieve | Weight Retained(gm) | Percentage weight retained | Cumulative percentage retained | Percentage passing |
|---|---|---|---|---|---|
| 1. | 40mm | 0 | 0 | 0 | 100 |
| 2. | 20mm | 877 | 17.54 | 17.54 | 82.46 |
| 3. | 10mm | 4085 | 81.70 | 99.24 | 0.76 |
| 4. | 4.75mm | 38 | 0.76 | 100.00 | 0 |
| 5. | 2.36mm | 0 | 0 | 100.00 | 0 |
| 6. | 1.18mm | 0 | 0 | 100.00 | 0 |
| 7. | 600µ | 0 | 0 | 100.00 | 0 |
| 8. | 300µ | 0 | 0 | 100.00 | 0 |
| 9. | 150µ | 0 | 0 | 100.00 | 0 |
| Total: | | | | 716.78 | |

Fineness modulus = 716.78/100 =7.17

### D. Water

The most crucial and affordable component of concrete is water. The concrete is mixed with fresh, drinkable water that is devoid of oil and organic material. By using a graduated jar to measure the water, the necessary amounts were added to the concrete. The other components for creating the concrete mix were obtained through weight batching. No lower than 6 should be the pH value. The outcomes and the acceptable limits for solids are shown.
Water Analysis (Limitations Per IS 456: 2000)

Table 6: water pH value

| S.NO | Parameter | Max. Limit | Results |
|---|---|---|---|
| 1. | pH value | 6 to 8.5 | 7.4 |

### E. Super plasticizer (fosroc conplast sp430)

Conplast SP430 is a super plasticizing admixture free of chloride that is based on certain sulphonated naphthalene polymers. It is provided as a dark solution that dissolves quickly in water. Conplast SP430 evenly distributes the cement granules in the concrete mixture, enhancing the performance of the concrete's water content. Significant strength gains are also made possible by the very high levels of water reduction that are feasible.

## V. EXPERIMENTAL INVESTIGATION

### A. Mix Design

According to IS 10262: 2009, mix proportioning for M40 grade and M60 grade concrete is carried out in the current experiment. The results of the mix design calculations for M40 and M60 are displayed in Annexures I and II, respectively. For M40 grade concrete, the results of the calculations are published, and for M60 grade concrete, they are shown in table 4.2.

Table 7: Quantities for M40 Grade Concrete

| S.NO | $TiO_2$ (%) | Cement (Kg) | $TiO_2$ (gms) | Fine Aggregate (Kg) | Coarse Aggregate (Kg) | | S.P (0.8%) Ml | Water (Liters) |
|---|---|---|---|---|---|---|---|---|
| | | | | | 20 mm | 10 mm | | |
| 1 | 0 | 34.759 | 0 | 52.640 | 69.053 | 34.011 | 278.072 | 12.165 |
| 2 | 0.5 | 34.585 | 173.795 | 52.640 | 69.053 | 34.011 | 276.680 | 12.165 |
| 3 | 1 | 34.411 | 347.59 | 52.640 | 69.053 | 34.011 | 275.288 | 12.165 |
| 4 | 1.5 | 34.237 | 521.385 | 52.640 | 69.053 | 34.011 | 273.896 | 12.165 |
| 5 | 2 | 34.063 | 695.180 | 52.640 | 69.053 | 34.011 | 272.504 | 12.165 |

### B. Mixing

The goal of mixing is to evenly distribute cement paste across the surface of every aggregate particle and to bring all the components of concrete together into one mass. Both manual mixing and machine mixing can be used to combine substances. Machine mixing is used in this investigation. Utilized is a tilting mixer with an 80 lit capacity. For around three minutes, combine all the dry ingredients in the mixer. When the mixture is homogenous and has enough workability, add the water and mix for an additional four minutes.

### C. Casting of Specimens

- Before concrete is put into the cast iron molds, the molds are thoroughly tightened, cleansed of any dust, and coated with mineral oil. The molds are set on the table vibrating machine's level platform. Three layers of concrete are poured into the molds, and after that, they are vibrated. A trowel is used to remove extra concrete, and the top surface is polished to conform to IS 516-1959 standards for mould level and smoothness.
- To determine compressive strength, 100 mm x 100 mm x 100 mm cube-shaped specimens are cast.
- In order to determine the split tensile strength, cylindrical specimens with dimensions of 100 mm x 200 mm are cast.
- To determine flexural strength, 500 mm by 100 mm by 100 mm beams are cast.

### D. Curing of Specimens

After casting, the specimens are kept in the molds at room temperature for around 24 hours without being touched. The specimens are taken out of the molds and placed right away in one of the several fresh water-filled curing tubs. Every seven days, new water is added.

### E. Workability

Fresh concrete has the quality of being workable. Workability, according to ACI, is the characteristic of newly mixed concrete or mortar that defines how easily and uniformly it can be mixed, transported, placed, compacted, and finished. The concrete's workability can be evaluated in a variety of ways. In this instance, workability is evaluated using the slump cone.

### *F. Slump cone test*

A lot of sites all around the world employ this test. The slump test is highly helpful in identifying deviations in the homogeneity of a mix of specified nominal proportions even though it does not assess the workability of concrete. The slump test is conducted in accordance with IS: 1199-1959.

A 300 mm high cone-shaped frustum serves as the slump mold. The smaller entrance is at the top, it is set on a smooth surface, and three layers of concrete are poured within. With a normal 16 mm diameter steel rod that is rounded at the end and used to tamp each layer 25 times, the top surface is then knocked off using a device of sawing and rolling motion of the tamping rod. The mould must be firmly against its base during the entire operation; this is facilitated by handles or foot-rests brazed to the mould. Immediately after filling, the cone is slowly lifted vertically up, and the unsupported concrete will now slump – hence the name of the test. The decrease in the height of the slumped concrete is called slump, and is measured to the nearest 5 mm.

### *G. Compaction factor test*

There is no generally accepted method of directly measuring the amount of work necessary to achieve full compaction, which is a definition of workability. Probably the best test yet available uses the inverse approach: the degree of compaction achieved by a standard amount of work is determined. The work applied includes perforce the work done against the surface friction but this is reduced to a minimum, although probably the actual friction varies with the workability of the mix. The degree of compaction, called compacting factor, is measured by the density ratio, i.e. the ratio of the density actually achieved in the test to the density of the same concrete fully compacted.

The test known as the compacting factor is described in IS: 516 and is appropriate for concrete with a maximum size of aggregate up to 40 mm. the apparatus consists essentially of two hoppers, each in the shape of the frustum of a cone, and one cylinder of 15cm and 30cm internal height and internal diameter respectively, the three being above one another. The hoppers have hinged doors at the bottom. All inside surfaces are polished to reduce friction.

The upper hopper is filled with concrete; this being placed gently so that at this stage no work is done on the concrete to produce compaction. The bottom door of the hopper is then released and the concrete falls into the lower hopper, this is smaller than the upper hopper one and is, therefore, filled to overflowing, and thus always contains approximately the same amount of concrete in a standard state; this reduces the influence of the personal factor in filling the top hopper. The bottom door of the lower hopper is then released and the concrete falls into the cylinder. Excess concrete is cut by two floats slid across the top of the mould, and the net mass of concrete in the known volume of the cylinder is determined.

The weight of the concrete in the cylinder is now, calculated, and this weight is divided by the weight of the fully compacted concrete is defined as the compacting factor. The latter weight is obtained by filling the cylinder with concrete in four layers, each tamped 25 times with 16 mm diameter tamping rod with rounded end or vibrated.

### *H. Compression Test*

Compression test was conducted on 100 mm×100 mm × 100 mm cube specimens using Compression Testing Machine. The specimen is placed in the machine with the cast faces at right angles to that of compressive faces and then load is applied at a constant rate of 140 kg/cm2 /minute up to failure and the ultimate load is noted. The load is increased until the specimen fails and the maximum load is recorded. The test was conducted on specimens cured for 3 days, 7 days and 28 days. The average strength of three specimens was reported as the compressive strength of the specimen.

Compressive Strength =Ultimate Load/Area of Cross section

## VI. RESULTS AND DISCUSSIONS

Concrete with or without replacement of cement with Nano TiO2 is investigated by conducting workability tests in accordance with IS 1199-1959 and strength tests in accordance with IS 516-1959. The values obtained by experimental investigation are tabulated and represented in charts to show the workability, compressive strength, split tensile strength and flexural strength of concrete.

### *A. Workability Tests*

The workability test results are obtained by conducting slump cone test and compaction factor test for M40 and M60 grade concrete with partial replacement of cement with Nano TiO2 by 0.5%, 1%, 1.5% and 2%

Table 8: Workability Test results for M40 grade concrete

| S.No | % $TiO_2$ | Slump(mm) | Compaction Factor |
|---|---|---|---|
| 1 | 0 | 44 | 0.882 |
| 2 | 0.5 | 35 | 0.854 |
| 3 | 1.0 | 32 | 0.846 |
| 4 | 1.5 | 26 | 0.842 |
| 5 | 2.0 | 21 | 0.821 |

observed that values obtained by slump and compaction factor tests are decreased with the increase in % of Nano TiO2. In mix design of M40 grade concretes workability is assumed as in terms of slump as 50mm and in terms of compaction factor as 0.8, but the test results shown decrease in values of slump and compaction factor which might be because of increase in powder content lead to prevention of free movement of particles. Considerable difference is not found between M40 grade concretes in the values of slump and compaction factor tests for all the percentage of replacements of cement with Nano TiO2

### *B. Compressive Strength*

The compressive strength of conventional and simultaneously replacement for M40 and M60 grade concrete, is determined by testing 100 mm x 100 mm x 100 mm cubes for 7 days, 14 days and 28 days' strengths in compression testing machine. Cubes about a total number of 90 specimens from all 10 mix proportions are tested. Minimum of 3 specimens are tested to obtain test strength from each variation.

Table 9: Compressive Strength Test Results for M40 grade concrete.

| S.No | % of $TiO_2$ | Compressive Strength ($N/mm^2$) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0 | 30.36 $N/mm^2$ | 39.93$N/mm^2$ | 57.5$N/mm^2$ |
| 2 | 0.5 | 30.2 $N/mm^2$ | 39.6 $N/mm^2$ | 58.5 $N/mm^2$ |
| 3 | 1 | 34.73 $N/mm^2$ | 42.83 $N/mm^2$ | 62.33 $N/mm^2$ |
| 4 | 1.5 | 33.66 $N/mm^2$ | 41.66 $N/mm^2$ | 57.1 $N/mm^2$ |
| 5 | 2 | 29.2 $N/mm^2$ | 36.6 $N/mm^2$ | 48.33 $N/mm^2$ |

From the above tables it is found that at 1% replacement of cement with Nano TiO2 shown maximum values for all the periods of curing. Therefore 1% of Nano TiO2 content can be optimum content in cement concrete. The compressive strength of M40 grade concrete with 1% Nano TiO2 content is 8% more than same M40 conventional concrete. The compressive strength of M60 grade concrete with 1% Nano TiO2 content is 7% more than same M60 conventional concrete. Further increase in replacement of cement with Nano TiO2 resulted decrease in strength which might be because of reduction in space available for development of C-S-H gel. Compressive strength testing Machine and Specimen from all the percentages of replacements for M40 grade concrete it can be observed that the maximum compressive strength is 62.33 N/mm2 and lowest compressive strength is 48.33 N/mm2.

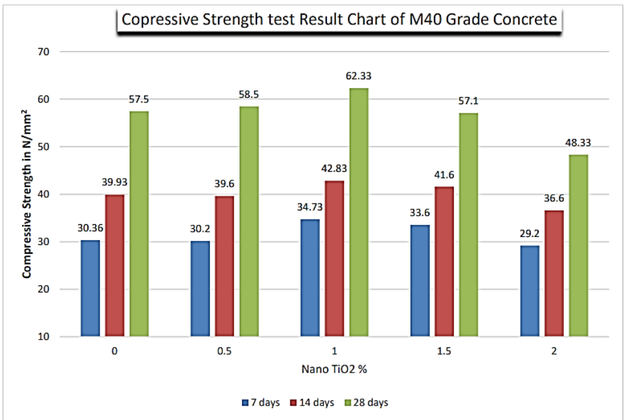


Figure 1: Compressive strength chat of M40 grade concrete

Effect of Nano TiO2 on compressive strength of M40 grade concrete

## VII. CONCLUSIONS

- The workability of concrete is decreased with the increase in the percentage of Nano Titanium Dioxide (TiO2).
- It is observed that increase in powder content of Nano TiO2, reduces the free movement of particles in fresh mix thus concrete mix becomes stiffer resulting decrease in slump and compaction factor.
- For M40 grade concrete, maximum values for compressive strength are obtained at 1% Nano TiO2 as 62.33 MPa at 28 days and Lowest compressive strength is 48.33 MPa at 28 days.
- From the results it is observed that 1% Nano TiO2 content for the grade of concrete yielded maximum values; hence it can be concluded as optimum content. Further increase in percentage of Nano TiO2 content strengths are decreased.
- Increase in strength up to 1% Nano TiO2 grade of concrete M40, which might be cause of pore space available for development of C-S-H gel.

Further increase in Nano TiO2 content resulted decrease in strength which might be cause of reduction of pore space for growth of C-S-H gel. From the results it is concluded that replacement of Nano TiO2 in cement concrete obtained better results compared to the conventional concrete. This concrete is also known as Green Concrete due to the self-cleaning property of the Nano material. This concrete is used at the places where high strength is required and also reduces the permeability.

## VIII. FUTURE WORK

- Durability aspects such as porosity, water absorption, permeability, self-weight attack resistant and abrasion resistance for Nano concrete may be studied.
- Future research may be carried out by different types of curing (membrane curing, steam curing).
- Mechanical properties of Nano concrete is also studied by using light weight aggregates.
- The Research work may be carried out by adding different types of fibers like steel fibers, polyester fibers, glass fibers, Nylon fibers etc.,

Research work may be carried out to develop reinforced Nano concrete elements like beams and slabs.

## ANNEXURE

1 MIX PROPORTION FOR M40

- TARGET STRENGTH F

1*ck = fck+1.65*s
= 40+1.65*5
= 48.25 N/mm2

- SELECTION OF WATER CEMENT RATIO

W/C ratio = 0.45 as per 10262:2009 Based on the mixed trails
w/c ratio = 0.43

- SELECTION OF WATER CONTENT

w/c ratio = 0.43
water =186 liters

selection of water content = 186/0.43
= 432.5 ~ 432 liters

- CALCULATION OF CEMENT CONTENT

w/c ratio = 0.43, 186/c
= 0.43,
c = 186/0.43 = 432 kg/m3

- MIX CALCULATIONS

a) volume of concrete = 1 m3
b) volume of cement = 432/2.27 * 1/1000 = 0.1905 m3
c) volume of water v =186/1 * 1/1000 = 0.186 litres
d) volume of total aggregates ={a-(b+c)}
= {1-(0.1905+0.186)}
= 0.6235
e) mass of coarse aggregate
= vol . of total aggregate * 0.64 * sp.gravity of coarse agg.*1000
= 0.6235 * 0.64 * 2.37 * 1000
= 945.72 ~ 946 kg/m3
f) mass of fine aggregate = vol.of total aggregates *
0.36 * sp.gravity of fine agg. * 1000
= 0.6235 * 0.36 * 2.66 * 1000
= 597.06 ~598 kg/m3

Table no-10: quantity of aggregates for mixing

| Cement | Fine Aggregate | Coarse Aggregate | Water |
|---|---|---|---|
| 435 kg/m3 | 595 kg/m3 | 945 kg/m3 | 188 liters/m3 |
| 1 | 1.4 | 2.16 | 0.48 |

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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