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# STUDY OF MECHANICAL PROPERTIES OF CONCRETE WITH INCORPORATING NANO FERRIC OXIDE

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**Abstract-**
There is currently a great deal of demand for the application of nano materials to improve the qualities of traditional concrete. It was discovered that adding nano materials to concrete increases its durability and strength. By partially substituting cement with nano material on a weight basis to enhance the binding effect, the inclusion of nano material will aid in lowering the cement content. By serving as a filler agent and creating extremely dense concrete, the nano material's ultrafine particles will also aid in reducing the proliferation of microspores in ultra-high performance concrete structures. Additionally, this essay will explore the advantages and rewards of using Nano materials to improve concrete. This paper summarized that use of Nano Ferric oxide in concrete at an interval of 0.3% 0.6% ,0.9% ,1.2% and 1.5% for replacement of cement and check its effect on mechanical Properties like compressive strength split tensile strength, flexural strength.

**Keywords-** — Nano materials, Nano Ferric Oxide workability, Compressive strength, Split tensile strength.

## I. INTRODUCTION

Worldwide, the construction industry uses concrete [1]. These structures can be used worldwide, from buildings to factories as well as bridges to airports, due to which it became the most investigated material of the 21st century [2]. Due to population expansion then technology boom to attend to these needs, need to improve strength and durability of concrete [3]. Various materials used in concrete out of which cement plays an important role due to its size and adhesive property. So, to make concrete with essential properties, the mechanism of cement hydration must be studied properly and better substitutes to it have to be suggested [4]. Different supplies known as supplementary cementations materials or SCMs are added to stabilize its properties some of these are fly ash, blast furnace slag, rice husk, silica fumes and bacteria [5]. Various technologies in use, Nanotechnology looks promising approach in improvising the properties of concrete [6]. Therefore, the fundamental idea behind nanotechnology is bottom-up engineering, beginning with designed modifications to molecular structure with a goal bulk property of material [7]. Conceptually, this is simply a copy of nature in practice; the introduction of nanotechnology represents a revolution that allowed for the development of high-performance and long-lasting products and processes within an ideal context of sustainable development [8].

Nano-materials are incredibly small substances containing nanometre-sized particles. Due to their extremely small size, these materials are exceptionally effective at altering the characteristics of concrete at the ultrafine level. The particles' tiny size also results in a larger surface area. A faster reaction can be accomplished since the pace of a pozzolanic reaction is related to the available surface area. To obtain the required outcomes, just a tiny portion of cement may be changed. By filling in the tiny gaps and pores in the microstructure, these nano particles increase the strength, longevity, and permeability of concrete [9].

Because the nano particles of silica in the concrete have the property of clogging pores, using nano-concrete also results in a decreased rate of corrosion of the steel reinforcing. There will be many prospects for more study and development of concrete used in the building industry if Portland cement can be produced utilising nanosized particles [10]. Additionally, the nano particles improve the cement's environmental friendliness and lessen the negative environmental effects of the building sector, resulting in a more sustainable future [11]. This process will produce cement that is not only

more affordable than conventional cement polymers, but also more fire resistant. Therefore, a structure constructed using nano particles will be more robust and long-lasting than one constructed with normal concrete, extending the building's useful life.

## II. MATERIALS

### Cement replacement by nano ferric oxide

Although copper, cobalt, and nickel are highly magnetic materials, they have very limited applications due to their toxicity and susceptibility to oxidation. Even though certain nano material has been extensively studied, there is still a high amount of available nano material which influence the properties of concrete still need to be revealed. Thestudies related to the application of iron oxides (especially $Fe_2O_3$) in cementations composites have shown that these nano materials positively influence the mechanical and micro structural properties by improving compressive and flexural strength and byreducing the total porosity of the composites. In addition, the application of Nano-$Fe_2O_3$can be very beneficial in improving the self-sensing properties of concrete

### Physical Properties

Physical properties help in classifying the coal ashes for engineering purposes and other engineering properties. Some of the properties discussed below are specific gravity, grain size distribution, index properties, free swell index and specific surface.

Table .1 Physical properties of Nano ferric oxide:

| Physical Properties | Ferric oxide |
|---|---|
| Average Particle Size | 10-100nm |
| Specific surface Area | 30 $m^2/g$ |
| Appearance | Red brown |
| True density | 3.21 $g/cm^3$ |
| Melting point | 1570$^o$ C |

### Specific gravity

One of the main physical qualities required for the use of coal ashes in geotechnical and other applications is specific gravity. Because of the low specific gravity of coal ash in comparison to soils, ash fills have low dry densities. The lower unit weight is advantageous when used as a backfill material. Other application areas include low-lying area reclamation, embankment construction, particularly on weak foundation soils, and so on. The specific gravity of coal ash varies due to a variety of parameters such as gradation, particle morphology, and chemical makeup. Coal ash is reported to consist primarily of glassy ecospheres and some solid spheres. A low specific gravity could be caused by one of two factors:

### Chemical properties-

The environmental effects that could result from the use or disposal of coal ashes, as well as their engineering properties, are primarily influenced by their chemical properties. The negative effects include loss of soil fertility near the plant sites, contamination of surface and subterranean water with harmful heavy metals found in the coal ashes, etc. Lime reactivity, PH, Total Solvable Solids, and Initial and Final Setting Times.

Table. 2 Chemical composition of Ferric oxide:

| Chemical composition | Cement (%) | Ferric oxide (%) |
|---|---|---|
| CaO | 60 - 67 | 62.7 |
| $SiO_2$ | 17 - 25 | 20.1 |
| $Al_2O_3$ | 3.0 - 8.0 | 5.4 |
| $Fe_2O_3$ | 0.5 - 0.6 | 3.2 |
| MgO | 0.1 - 4.0 | 1.3 |
| $K_2O$ | 0 - 1 | 0.7 |

| | | |
|---|---|---|
| $SO_3$ | 1.3 - 3.0 | 2.9 |
| Loss on Ignition | - | 3.5 |

## III. RESULTS

### Workability of individual blend of cement

The ability of concrete to overcome friction during compacting dictates how much meaningful internal work, or workability, is required to generate full compaction. The relative ease of mixing, moving, shaping, and compacting concrete. Test of concrete were carried out by using IS code [12-15]

**Table .3 Workability of Blended Cements.**

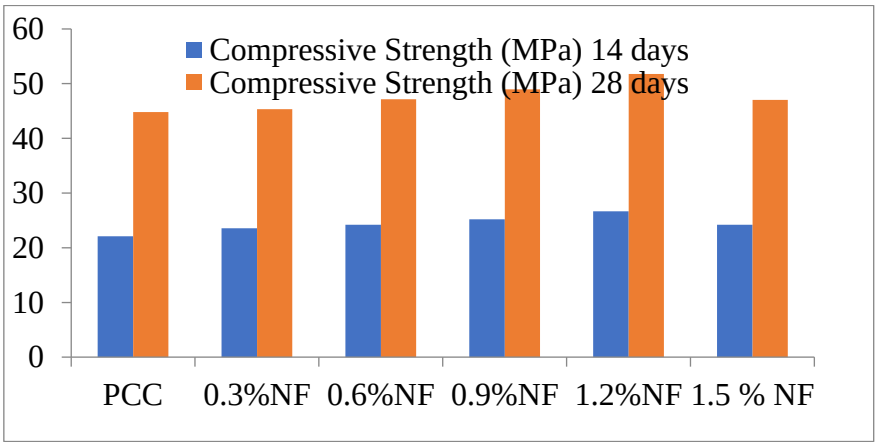
| Mix Combination | Slump ofconcrete | CompactionFactor | Workability |
|---|---|---|---|
| PCC | 89 | 0.887 | Medium |
| 0.3%NF | 66 | 0.87 | Medium |
| 0.6%NF | 58 | 0.85 | Medium |
| 0.9%NF | 68 | 0.88 | High |
| 1.2%NF | 69 | 0.84 | Medium |
| 1.5 % NF | 57 | 0.82 | Medium |

According to the results of the above workability test, 0.9% addition of Nano Ferric Oxide results in a higher workability rating, which gradually decreases.

**Compressive Strength of Concrete –** Concrete's compressive strength is described as a material or structure's capacity to support weights placed on it without cracking or deflecting. When a material is compressed, its size tends to decrease, and when it is stretched, its size elongates. Concrete compressive strength can be estimated by dividing the load applied to the concrete cube at the point of failure by the cross-section area of the cube (15x15x15 cm).

**Table 4 Various replacement level of cement for compressive strength**

| ReplacementLevels (%) | Compressive Strength(MPa) 14 days | 28 days |
|---|---|---|
| PCC | 22.12 | 44.80 |
| 0.3 % NF | 23.56 | 45.33 |
| 0.6% NF | 24.22 | 47.14 |
| 0.9% NF | 25.22 | 48.97 |
| 1.2% NF | 26.67 | 51.78 |
| 1.5 % NF | 24.20 | 47.05 |



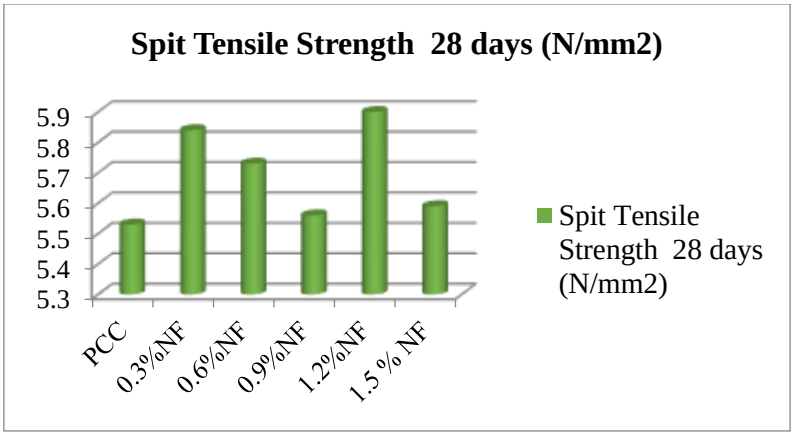

**Graph 1 - Various replacement level of cement for compressive strength**

Based on the compressive strength measurements presented above, we infer that 1.2 % addition of nano ferric oxide leads in the highest compressive strength when compared to conventional concrete.

**Split Tensile Strength of Concrete -** The split tensile test is an indirect method of assessing concrete tensile strength. In this test, a conventional cylindrical specimen is laid horizontally, and a force is exerted radial on the surface of the cylinder, causing a vertical crack to occur along its diameter. The table below displays the results of split tensile strength with varying percentages of nano ferric oxide added. and after 28 days of cure, the results were received

Table .5 Split tensile strength of various replacements

| ReplacementLevels (%) | Split TensileStrength 28 days (N/mm$^2$) |
|---|---|
| PCC | 5.53 |
| 0.3%NF | 5.84 |
| 0.6%NF | 5.73 |
| 0.9%NF | 5.56 |
| 1.2%NF | 5.90 |
| 1.5 % NF | 5.59 |




**Graph 2 - Various replacement level of cement for Split tensile strength**

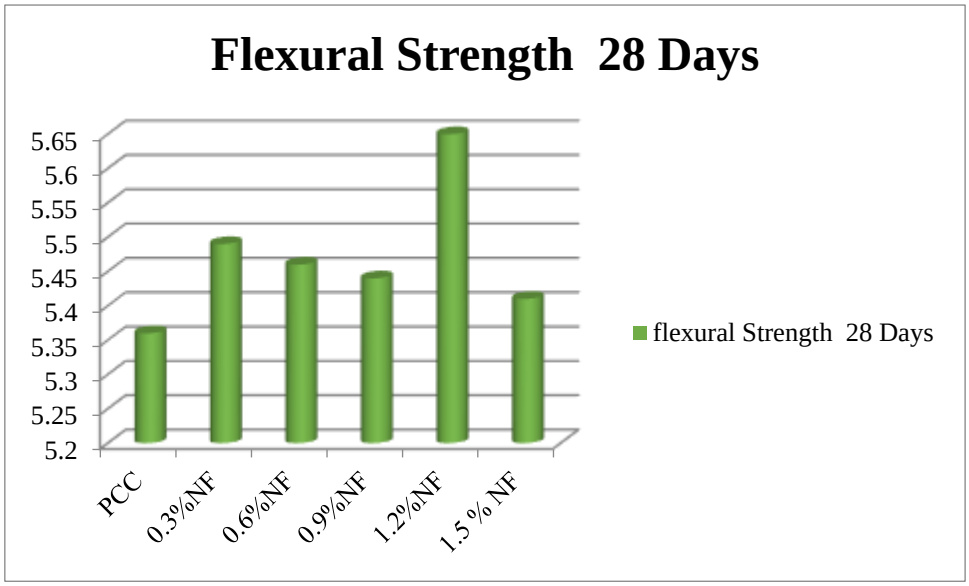
Based on the Split Strength measurements presented above, we infer that 1.2 % addition of nano ferric oxide leads in the highest Split Strength when compared to conventional concrete

**Flexural Strength -** Another type of indirect tension test is the flexural test or modulus of rupture. Under this procedure, two equidistant from the centre loadings are applied to the beam to produce the pure bending moment until the outermost fiber of the beam specimen under tension reaches the maximum tensile stress.

**Table. 6 Flexural Strength for various replacements**

| Identification Mark | Volume of NF | Crushing load (x10$^3$N) | Flexural Strength (N/mm$^2$) | Avg. Flexural Strength (N/mm$^2$) |
|---|---|---|---|---|
| PCC | 0% | 27.20 | 5.24 | |
| PCC | 0% | 28.20 | 5.60 | 5.36 |
| PCC | 0% | 26.14 | 5.23 | |
| 0.3%NF | 0.3% By mass | 26.70 | 5.34 | |
| 0.3%NF | 0.3% By mass | 28.50 | 5.7 | 5.49 |
| 0.3%NF | 0.3% By mass | 27.17 | 5.43 | |

| | | | | |
|---|---|---|---|---|
| 0.6%NF | 0.6% By mass | 26.00 | 5.2 | |
| 0.6%NF | 0.6% By mass | 29.50 | 5.9 | 5.46 |
| 0.6%NF | 0.6% By mass | 26.33 | 5.27 | |
| 0.9%NF | 0.9% By mass | 27.20 | 5.44 | |
| 0.9%NF | 0.9% By mass | 28.29 | 5.66 | 5.44 |
| 0.9%NF | 0.9% By mass | 26.14 | 5.23 | |
| 1.2%NF | 1.2% By mass | 28.20 | 5.52 | |
| 1.2%NF | 1.2% By mass | 29.02 | 5.9 | 5.65 |
| 1.2%NF | 1.2% By mass | 27.80 | 5.8 | |
| 1.5%NF | 1.5% By mass | 26.12 | 5.3 | |
| 1.5%NF | 1.5% By mass | 29.01 | 5.5 | |
| 1.5%NF | 1.5% By mass | 26.03 | 5.2 | 5.41 |




**Graph 3 - Various replacement level of cement for Flexural strength**

Based on the Flexural Strength measurements presented above, we infer that 1.2 % addition of nano ferric oxide leads in the highest Flexural Strength when compared to conventional concrete

## IV CONCLUSIONS

This was done to investigate how Nano-$FeO_3$ (NF) affected several concrete parameters, including flexural strength, splitting tensile strength, and water absorption. The outcomes are as follows.

- By replacing cement with a tiny fraction of Nano Ferric oxide material, early compressive strength of mortar is attained.
- Fe2O3 nanoparticles can be successfully used as a cementitious material additive, and their presence has no effect on the rate of cement hydration or the nature of the phases in hydrated cement paste.
- The partial replacement of the cement by iron powder improved significantly the compressive strength in comparison of the concrete without iron powder ($Fe_2O_3$) particles. It is found that it is advantageous if cement is replaced by iron powder.
- The water absorption of the hardened concrete increased when the percent content of iron powder increased.
- The slump of the fresh concrete decreased with the increase of the amount of the iron powder particles.

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