Influence of Nano Alumina And Supplementary Cementitious Pozzolanic Material on Properties of Different Grades of Concrete

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Abstract- *Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country's development. It's known that some waste product like nano alumina and metakaolin are having some building material and siliceous properties. The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Nano alumina and metakaolin like waste materials comprise pozzolanic properties but their disposal is causing acute environmental setbacks. This project work is carried to focuses on the effect of study of incorporating of Nano particle like Nano Alumina (NA) and also one of the supplementary cementitious (pozzolanic) materials in concrete to enhance the mechanical properties of the concrete. . Nano particle and pozzolanic material is partially substituted by the weight of cementitious material into concrete. The experimental investigation was carried out on Nano modified concrete were tested after 7, 14 and 28 days of water curing for different grades like M30, M40 and M50 to determine the mechanical properties of concrete like compressive strength, split tensile strength and flexural strength of concrete specimens.*

Keywords- Nano Alumina, metakaolin, workability, compressive strength, split tensile strength test, flexural stregth.

I. INTRODUCTION

In the last decades, environmental sustainability has become one of the most important issues. Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country's development. it's known that some industrial waste product like nano Alumina are having some building material and silicious properties. So the use of the commercial and agricultural wastages in concrete part as cement replacement, scale back the price of constructing concrete, additionally causes improvement within the properties of concrete and scale back environmental pollution. Rapid industrial expansion produces severe difficulties all around the world, including as the depletion of natural resources and the creation of vast amounts of waste materials throughout the manufacturing, construction, and demolition stages; one option to mitigate this problem is to utilize wastes.

The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Nano alumina and metakaolin do waste materials comprise pozzolanic properties but their disposal is causing acute environmental setbacks. The utilization of industrial and agricultural waste product in concrete has been a major step on waste reduction. Metakaolin and Nano Alumina can by effectively used in concrete as partial replacement of cement because of their high content of Alumina and pozzolanic properties which plays an important role in achieving high strength and durability in concrete.

In the research work the influence of Nano particle like Nano Alumina andalso one of the supplementary cementitious (pozzolanic) materials like metakaolin in concrete to improve the mechanical properties of standard and high strength concrete. The Nano particle like Nano Alumina and pozzolanic material like metakaolin were partially replaced with cement by 1% and 15% respectively in the concrete mixtures for different grades of concrete.

The Nano particle will result in greater performance in strength and sustainability. The partial replacement of cement by a mineral admixture called metakaolin will shows better performance in both higher performance and economy. The concrete introduced with a combination of Nano particle and mineral admixture improves the micro structure as well as

decrease the calcium hydroxide concentration by consuming it through a pozzolanic reaction. The subsequent modification of the micro structure cement composites improves the mechanical properties, workability properties and increase the service life properties contributing to sustainably built environment.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength and impact resistance of concrete with different percentages replacement of cement with nano Alumina and metakaolin and to study the tensile behaviour on adding with nylon fibres.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

1. Workability
2. Compressive strength
3. Flexure strength
4. Tensile strength

II. REVIEW OF LITERATURE

A lot of work has been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Literature review of nano Alumina and metakaolin is presented in the following sections.

It has been noted that the sunshine fastness of banana fibre is inferior to cotton. this could be attributed to the impurities gift within the banana fibre within the variety of polymer and therefore the different insoluble matter. The revealed analysis works on flexural plasticity of nylon fiber ferroconcrete beam are studied by several researches few mentioned the influence of nylon fiber issue on flexural plasticity of beam and terminated that plasticity indexes increase with increasing of fiber issue.

D. Patil, Patil&Veshmawala Observed the Performance of Copper Slag as Sand Replacement in Concrete.M30 concrete was used and several tests like compressive, flexural, split tensile strength were taken for different portions of copper slag and sand from 0 to 100%. The outcome showed that workability increases with growth in percentage of copper slag. Maximum Compressive strength of concrete increased by 34 % at 20% replacement of fine aggregate with copper slag, and up to 80% replacement of copper slag, concrete gain more force than normal concrete strength. The flexural strength of concrete found to be increased by 14% with 30% substitution of copper slag.

Sasikumar&Tamilvanan Performed an Experimental Investigation on Properties of Alumina Fumes as a Partial Replacement of Cement. The main parameters investigated in this study is M30 grade concrete with partial replacement of cement by Alumina fume0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when the Alumina fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % Alumina fume replacement level. As well the split tensile strength is high when using 25% Alumina fume replacement for cement.

Ghutke&Bhandari Examine the Influence of Alumina fume in concrete. Results indicated that the Alumina fume is a better replacement of cement. The rate of strength gain in Alumina fume concrete is high. Workability of concrete decreases as increase with % of Alumina fume. The optimum value of compressive strength can be achieved in 10% replacement of Alumina fume. As strength of 15% replacement of cement by Alumina fume is more than normal concrete. The optimum Alumina fume replacement percentage is varying from 10 % to 15 % replacement level.

Deb, P. S., Nath, P., & Sarker, P. K. (2014): Metakaolin with mixture of flyash content showing huge improve in the consequences of workability and high strength contrasted with Ordinary Portland Cement (OPC). By changing dissimilar (0%,10% and 20%)contents of Metakaolin with various proportions of flayash content showing a few blemishes, One of them is with increment in metakaolin content workability is diminishing simultaneously strength is expanding. By keeping up Aluminates to alkaline proportions of 1.5 to 2.5 and following ACI 318 and AS 3600 codes for curing we can accomplish above outcomes when contrasted with OPC.

Goriparthi, M. R., & TD, G. R. (2017): He arranged geopolymer concrete consolidating fly ash and metakaolin as a limiting material, Alkaline materials Sodium Aluminate (Na2SiO3) and Sodium Hydroxide (NaOH) as activators. And contrasted the consequences of both OPC and geopolymer concrete and closed the accompanying aftereffects of two evaluations of concrete GPC20 AND GPC50. Significant boundaries of corrosive mass misfortune factor (AMLF) by submerging in 5% of H2SO4 solution and strength properties (Compressive, Tensile and Flexure) were resolved.

MallikarjunaRao, G., &GunneswaraRao, T. D. (2018): In this paper a broad research was done to discover the

plan mix and routine properties of geopolymer concrete. Mr. MallikarjunaRao got ideal outcomes with 30% replacement of metakaolin with fly ash. Proportion between alkaline solution and binder of 0.5 invigorated better workability and compressive. He got effective to take out broiler curing and supplanted it with encompassing curing interaction to try not to cure issues related with it by supplanting metakaolin in the spot of fly ash. It is seen that metakaolin and fly ash based geopolymer concrete is giving preferred outcomes over fly ash based geopolymer concrete. Various molarities were tried and best economic molar focus is discovered alongside strength and workability.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Nano Alumina
5. Metakaolin

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Nano alumina

The properties of Nano particles are particle size, purity, specific gravity, density and colour are shown in below tables

Table 3.1.Physical Properties of nano Alumina

S.No	Property	values
1	Morphology	spherical
2	Colour	White
3	Purity	99.9%
4	Particle size	30 – 50 nm
5	Specific gravity	3.9
6	Density	90 (g/l)

5. Metakaolin

Metakaolin is a white, amorphous, highly reactive aluminiumAluminate pozzoloan forming stabile hydrates after mixing with lime stone in water and providing mortar with hydraulic properties. It is a mineral admixture obtained from clay. Metakaolin is a highly pozzolanic material, it is in powder form and fineness of MK up to 700 to 800m²/kg. It is derived from the calcination of a high-purity kaolin clay. The product is then ground to between 1-2 gm. (about 10 times finer than cement). Indeed Metakaolin is not a by-product, one of the prominent use of MK is mixing with concrete because its physical and chemical properties are similar to the cement. As a raw material, it is rarely found in crystallized form and Kaolinite is a clay mineral found fairly commonly throughout the world.

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M35.

V. RESULTS AND DISCUSSIONS

This session provides an outline of the experimental results and endeavours to draw some conclusions. The take a look at result covers the workability, strength properties and sturdiness properties of concrete with and while not admixtures. The results of the experimental investigation on metakaolin and nano alumina concrete wherever metakaolin and nano alumina has been used as partial replacement of cement in concrete mixes. On commutation cement with

completely different percentages of metakaolin and nano alumina the workability, compressive strength is studied the compressive strength, split tensile strength and flexural strength for various mixes then studied.

REPLACEMENT DETAILS

The replacement details of nano Alumina and metakaolin has been given in the below table. The replacement of cement percentages by 0, 10, 20, 30% with metakaolin and 0, 2, 4, 6% nano Alumina and for getting optimum percentage

5.2 VARIATION OF SLUMP VALUES FOR PERCENTAGE REPLACEMENT OF NANO ALUMINA

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability. Critical mix has high workability compared to other mixes which may be due to the particle size of nano Alumina and metakaolin is lesser than cement. So in short, mixes with high percentages of nano Alumina are more workable than the control one.

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The slump of the freshly mixed concrete was measured by using a slump cone in accordance to ASTM C143. It can be observed from Table 5.1 that all mixtures have a slump of less than 45mm and are observed that slump values increasing with increase in slag content.

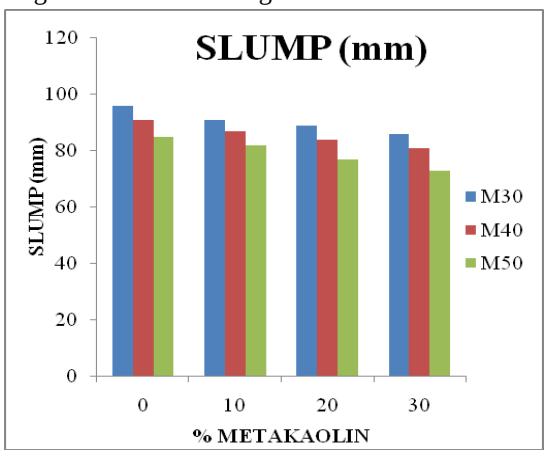

Fig 51: Plot shows the Variation of Slump Values for % replacement of metakaolin

5.3.1 COMPRESSIVE STRENGTH

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical cracks occur due to lateral tensile strain. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strain.

Cubes are prepared of size 150 mm x 150 mm x 150 mm are checked for compressive strength. The specimens tested for 7, 14 and 28 days. The specimen were tested for compressive strength parallel to the plane of the board by applying increasing compressive load until failure occur. The arrangement of load is applied to the specimen by placing the specimen length vertical between the surfaces of the testing machine. Prior to that, measurement for the thickness and width was carried out in order to get the values of cross section area for the test specimens.

Fig 5.2: Compressive Strength Testing machine

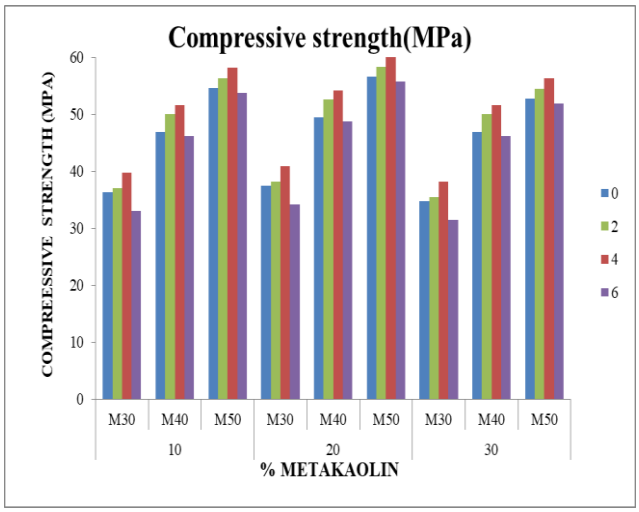

Fig 5.3: Plot shows the summarized results of compressive strength for different percentages of Nano alumina and Metakaolin-different grades

The significance of test results of obtained from the average of three samples. It is observed from the results that the specimens containing Nano particles show an increase in compressive strength when compared with the conventional concrete. The results exhibits that the concrete modified by 20% Metakaolin and of 4% Nano Alumina respectively of 11% , 12.6% and 7% enhanced in compressive strength with that of Normal concrete for 28 days for different grades like M30, M40 and M50 respectively. The enhancement of compressive strength of concrete can be mainly due to that Nano particles act as nuclei in promoting the cement hydration and filling up of pores to increment in the compressive strength of concrete. The influence of Nano Alumina particle and metakaolin in concrete improves the low early age compressive strength in concrete.

5.3.2 SPLIT TENSILE STRENGTH

The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per as per IS 516 (1959) and IS 5816 (1999).

5.3.3 VARIATION OF SPLIT TENSILE STRENGTH FOR DIFFERENT MIXES AND GRADES

The Split Tensile strength of the concrete mix for different grades with partial replacement of cement by metakaolin and nano alumina respectively showed higher Strength against splitting after 7 , 14 and 28 days for M30, M40 and M50 grades.

Split tensile test is also used to determine the tensile stress in concrete; this method is also called as Brazilin test. In this we place the cylindrical specimen of size 300 mm height and 150 mm diameter is placed in horizontal between the loading surfaces of compression test machine and load is applied until the failure of the specimen along the vertical diameter. This test is performed as per IS: 5816 code.

Compressive stress = 2P/πLD {D2 / (D−r)−1}
Tensile stress =2P / IIld

Where, P = Compressive load on cylinder
L = Length of cylinder =300 mm
D = Diameter of cylinder = 150mm
r& (D-r) are distance of the element from the two loads respectively.

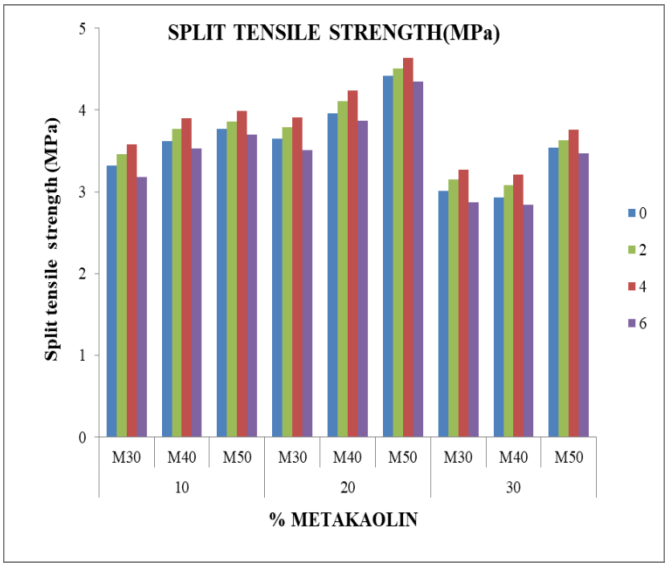

Fig 5.4: Plot shows the summarized results of split tensile strength for different percentages of Nano alumina and Metakaolin-different grades

The significance of test results of obtained from the average of 3 samples. It is observed from the results that the specimens containing Nano particles show an increase in split strength when compared with the conventional concrete. The results exhibits that the concrete modified by 20% Metakaolin and of 4% Nano Alumina respectively of 4.82% , 6% and 2% enhanced in split tensile strength with that of Normal concrete for 28 days for different grades like M30, M40 and M50 respectively. The enhancement of split tensile strength of concrete can be mainly due to that Nano particles act as nuclei in promoting the cement hydration and filling up of pores to increment in the compressive strength of concrete. The influence of Nano Alumina particle and metakaolin in concrete improves the low early age compressive strength in concrete.

5.3.4FLEXURAL STRENGTH

In the flexural strength test theoretical maximum tensile stress reached at the bottom fibers of the test beam is known as the modulus of rupture. When concrete is subjected to bending stress, compressive as well as tensile stresses are developed at top and bottom fibers respectively. If the largest nominal size of aggregate does not exceed 20mm, the dimension of specimen may be 150mm×150mm×700mm.

6.5.1 VARIATION OF FLEXURAL STRENGTH FOR DIFFERENT MIXES AND GRADES

The Flexural strength of the concrete mix for different grades with partial replacement of cement by metakaolin and nano alumina respectively showed higher

Strength against splitting after 7 , 14 and 28 days for M30, M40 and M50 grades.

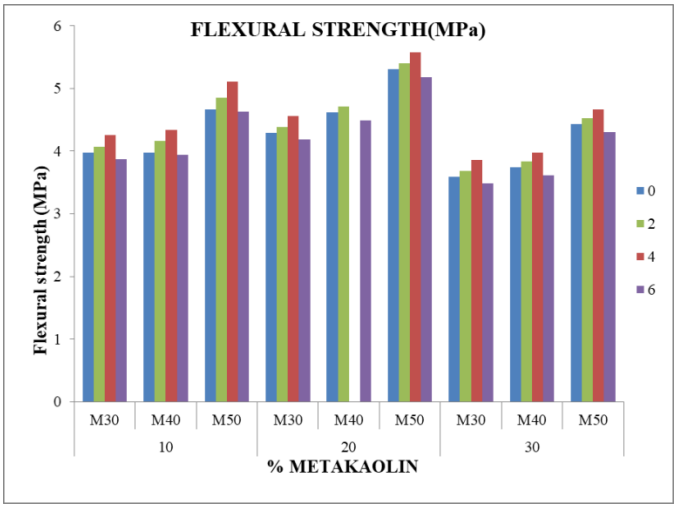

Fig 5.5 : Plot shows the summarized results of flexural strength for different percentages of Nano alumina and Metakaolin-different grades

The significance of test results of obtained from the average of 3 samples. It is observed from the results that the specimens containing Nano particles show an increase in flexural strength when compared with the conventional concrete. The results exhibits that the concrete modified by 20% Metakaolin and of 4% Nano Alumina respectively of 42% , 3.6% and 9.2% enhanced in flexural strength with that of Normal concrete for 28 days for different grades like M30, M40 and M50 respectively. The enhancement of split tensile strength of concrete can be mainly due to that Nano particles act as nuclei in promoting the cement hydration and filling up of pores to increment in the flexural strength of concrete. The influence of Nano Alumina particle and metakaolin in concrete improves the low early age flexural strength in concrete.

VI. CONCLUSIONS

The Conclusions and Recommendations that could be drawn from the results of this project and experiments are summarized and the use of nano alumina and metakaolin as a cement replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

- It has been observed that by the incorporation of metakaolin as partial replacement to cement and nano alumina as addition in fresh and plain concrete increases workability when compared to the workability of conventional concrete.
- It is clearly observed that the concrete modified by 20% Metakaolin and of 4% Nano Alumina respectively of 11%, 12.6% and 7% enhanced in compressive strength with that of Normal concrete for 28 days for different grades like M30, M40 and M50 respectively.
- The enhancement of compressive strength of concrete can be mainly due to that Nano particles act as nuclei in promoting the cement hydration and filling up of pores to increment in the compressive strength of concrete. The influence of Nano Alumina particle and metakaolin in concrete improves the low early age compressive strength in concrete.
- The results exhibits that the concrete modified by 20% Metakaolin and of 4% Nano Alumina respectively of 4.82% , 6% and 2% enhanced in split tensile strength with that of Normal concrete for 28 days for different grades like M30, M40 and M50 respectively.
- From the results it is noted that the concrete modified by 20% Metakaolin and of 4% Nano Alumina respectively of 42%, 3.6% and 9.2% enhanced in flexural strength with that of Normal concrete for 28 days for different grades like M30, M40 and M50 respectively.
- It is evident from the present investigation, influence of metakaolin and Nano Alumina will improves the micro structure as well as decrease the free calcium hydroxide concentration by consuming it through a pozzolanic reaction.
- The use of metakaolin and nano alumina combined is economic when compared to cement in concrete. Likewise saves a great deal of waste disposal problems and reduces the cement price rise and intensities of CO2 release by the cement production. .

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