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# Experimental Comparative Study by using Nano CaCo<sub>3</sub> and Nano Fe<sub>2</sub>O<sub>3</sub> in Fly Ash containing Concrete

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Abstract: The application of nano material in concrete has added a new dimension to the efforts to improve its properties. Nano materials by virtue of their very small particles size can affect the concrete properties by altering the microstructure. In these study i completed a work of literature review. In the literature review I study a various nano materials used in the concrete and its effects on the properties of concrete. there are a various nano materials used in the concrete such as nano SiO<sub>2</sub>, nano Fe<sub>3</sub>O<sub>4</sub>, nano CaCo<sub>3</sub>, nano ZrO<sub>2</sub>, nano CuO, nano Fe<sub>2</sub>O<sub>3</sub>, nano TiO<sub>2</sub>, nano ZnO<sub>2</sub>, nano Al<sub>2</sub>O<sub>3</sub> etc. By reffered a various research paper I decided that a in these study i note down that a nano CaCo<sub>3</sub> are improved a concrete compressive strength and durability properties and nano  $Fe_2O_3$  are improve in such case flexural strength and in such a case improve the compressive strength and the durability properties. So, I Perform the experimental work to uses a nano  $CaCo_3$  and nano  $Fe_2O_3$  material replacement by the cement. Also replacement of the fly ash by the cement. Find out the compressive strength of different proportion of nano CaCo<sub>3</sub> and nano Fe<sub>2</sub>O<sub>3</sub> and fly ash .Finally decided a optimum percentage is 1 % both nano CaCo<sub>3</sub> and nano Fe<sub>2</sub>O<sub>3</sub> and 30 % fly ash. We concluded that the maximum compressive strength are occure at the 1 % CaCo<sub>3</sub> and 30 % fly ash. The compressive strength is 40.25 MPa at 28 days, the maximum compressive strength are occure at the 1 % Fe  $_2O_3$  and 25 % fly ash. The compressive strength is 40.25 MPa at 28 days. For check out the tirtary effect of the fly ash, nano Fe  $_{2}O_{3}$  and nano CaCo<sub>3</sub> the optimum % of nano Fe 2O3 and nano CaCo3 are taken as 1% and fly ash is 30%. In the optimum specimen the strength of the optimum specimen is 38.84 MPa at 28 Days and the compressive strength of normal concrete is 32.15 MPa at 28 days. The flexural strength and the splite tensile strength are good with compared to the normal concrete. There are no carbonation effect on the concrete. to provide a durable concrete in these study.

Keywords: Concrete, nano material, compressive strength, durability properties, flexural strength, splite tensile strength, carbonation

## I. INTRODUCTION

A Concrete structure are usually exposed environmental conditions. Such as that involving chlorides, which may impact the mechanical and durability properties of the reinforced concrete structure through rebar corrosion. A strong and durable concrete can be produced by improving the behaviour of cement mortar. Various mineral additives such as fly ash and silica fume have been traditionally utilise composites not only for their environmental and economic advantages, but also for their technical benefits such as the ability to fill in micro and macro voids and displaying partial binder effect. The fly ash is used in concrete industries to reduced the amount of cement and to enhance durability and mechanical properties of concrete. Many of the available studies have focused on the uses of different types of nano materials such as nano SiO<sub>2</sub>,nano Fe<sub>3</sub>O<sub>4</sub>, nano CaCo<sub>3</sub>, nano ZrO<sub>2</sub>, nano Al<sub>2</sub>O<sub>3</sub> etc. Are effect on the properties of hardened cement paste, cement mortar and/ or concrete. Results of this study showed that nano particles can be very effective in improvement of both mechanical properties and durability of concrete.

Nano materials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area . Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved . Only a small percentage of cement can be replaced to achieve the desired results. These nano materials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure.



By using a nano materials in concrete the surface area of the nano material are high so improve the mechanical properties of the concrete. The different nano materials are different durability properties so to improve the durability properties of the concrete. Different Nano materials use in concrete are Nano-SiO<sub>2</sub>,Nano-Fe<sub>2</sub>O<sub>3</sub>,Nano-ZrO<sub>2</sub>,Nano-TiO<sub>2</sub>,NanoAl<sub>2</sub>O<sub>3</sub>,Nano carbon tube, Nano ZnO<sub>2</sub>,Nano CuO, Nano Fe<sub>3</sub>O<sub>4</sub>,Nano CaCo<sub>3</sub> etc....

The use of fly ash as partial replacement of cement in concrete is a common practice for many decades. During 2010–2012, the utilization of fly ash for construction application has achieved approximately 55% and become a commercial product which is the utilization of high volume fly ash in concrete addresses the challenges of sustainable construction. Chemically, fly ash has pozzolainic activity which is attributed to the presence of SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>. It reacts with calcium hydroxide (C-H) during cement hydration, to form additional calcium silicate hydrate(C-S-H) and calcium alluminate hydrate (C-A-H) which are effective in forming denser matrix leading to higher strength and better durability.

#### II. MIX PROPORTION OF CONCRETE

A. The Concrete Mix Design Of M 25 is Done.

For a batch of 6 cubes of 150mm size, the volume of concrete required =  $(0.15)3 \times 6 \times 1.2 = 0.024$ m<sup>3</sup> (taking into account 20 % extra for losses).

Cement required = 0.024x433 = 10.40 kg

Fine aggregate required = 0.024x614 = 14.73kg

Coarse aggregate required =  $0.024 \times 1192 = 26.60 \text{ kg}$ 

Water required =  $0.024 \times 186 = 4.46$  L

## **III. MATERIAL PROPERTIES**

#### A. Fly Ash

The use of fly ash as partial replacement of cement in concrete is a common practice for many decades. During 2010–2012, the utilization of fly ash for construction application has achieved approximately 55% and become a commercial product which is the utilization of high volume fly ash in concrete addresses the challenges of sustainable construction. Chemically, fly ash has pozzolainic activity which is attributed to the presence of SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>. It reacts with calcium hydroxide (C-H) during cement hydration, to form additional calcium silicate hydrate(C-S-H) and calcium alluminate hydrate (C-A-H) which are effective in forming denser matrix leading to higher strength and better durability.

Chemical	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	MnO	K <sub>2</sub> O	Na <sub>2</sub> O	TiO <sub>2</sub>	SO <sub>3</sub>
Analysis										
Content (%)	51.80	26.40	13.20	1.61	1.17	0.10	0.68	0.31	1.44	0.21
Physical	Particle	Specific	Los on	-	-	-	-	-	-	-
Properties	Size	Gravity	Ignition(%)							
Content (%)	40% of	2.6	0.5	-	-	-	-	-	-	-
	10µm									

TABLE.1 .Properties of Fly Ash

## B. Nano Materials

Nano materials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area . Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved . Only a small percentage of cement can be replaced to achieve the desired results. These nanomaterials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure .In these study I uses a nano CaCo<sub>3</sub> And Nano Fe<sub>2</sub>O<sub>3.</sub>



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<b>TABLE.2</b> Properties	of nano material
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Sr. No.	Parameters	Nano CaCo3 Properties	Nano Fe <sub>2</sub> O <sub>3</sub> Properties
1	Physical state and appearance	Fine White Powder	Brown powder
2	Molecular Weight	100 g/mol	155 g/mol
3	Color	White	Brown
4	Average Particle Size	80 nm	20-50 nm
5	Surface area	20-40 m <sup>2</sup> /gm	142 m2/gm
6	Bulk density(g/cm <sup>3</sup> )	0.68	0.25
7	PH	8.5-9.5	-
8			99.9%
	Purity	98%	

## C. Cement

The cement used in all mixtures is commercially available ordinary Portland cement of 53 grade confirming to IS : 12269-2013 is used in preparing a concrete specimen . Cement is a fine and genies grey powder. Cement is mixed with water and material such as sand ,aggregate to make concrete.

Chemical Requirements	Test Result	Requirement of IS:12269-2013		
Fineness (m <sup>2</sup> /gm)	311	225(Min.)		
Standard Consistency(%)	30			
Setting Time(minutes)				
Initial	185	30 (Min.)		
Final	290	600 (Max.)		
Soundness				
Le-Chat Expansion(mm)	0.7	10 (Max.)		
Autoclave Expansion(%)	0.052	0.8 (Max.)		
Compressive Strength(MPa)				
3 days	38	27 (Min.)		
7 days	50	37 (Min.)		
28 days	66	53 (Min.)		
Limestone(%)	4.9	5 (Max.)		

TABLE.3 Properties of 53 Grade cement

# D. Fine And Coarse Aggregate

Sand as fine aggregates are collected from locally available river SARASVATI and the sieve analysis of the samples are done. It is found that the sand collected is conforming to IS: 383-1970. For coarse aggregate, the parent concrete is crushed through mini jaw crusher. During crushing it is tried to maintain to produce the maximum size of aggregate in between 20mm to 4.75mm.

	1 66	8
Properties	Coarse Aggregate	Fine Aggregate
Specifit Gravity	2.71	2.56
Bulk Density(kg/L)	1.40	-
Loose Bulk Density(kg/L)	1.25	-
Water Absorption(%)	4.46	0.065
Impact Value	26.91	-
Crushing Value	26.51	-
Fineness Modulus	3.38	3.13



#### E. Water

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The water used in the manufacturing of concrete is portable water, water is needed for hydration of cement and molding of concrete to the desired shape. The relationship between compressive strength and water to cement ratio is well established. An increase in water to cement ratio leads to a reduction in compressive strength.

#### **IV. EXPERIMENTAL RESULTS**

#### A. Compressive Strength Test

The cube specimen size of 150mm×150mm×150mm are casted. The cube are casted for the results of 7 and 28 days. following are the cube ID for the compressive strength test of the different proportion of the fly ash, nano CaCo<sub>3</sub> And Nano Fe<sub>2</sub>O<sub>3</sub>. The C<sub>0</sub> Specimen is a control specimen.

						17101	LL.5 C		or un	lerent	cube sp	Jeenne	11						
CUBE	$C_0$	<b>C</b> <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	$C_4$	C <sub>5</sub>	C <sub>6</sub>	<b>C</b> <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>	C <sub>16</sub>	C <sub>17</sub>	C <sub>18</sub>
ID																			
FLY	0	25	25	25	30	30	30	35	35	35	25	25	25	30	30	30	35	35	35
ASH																			
(%)																			
Fe <sub>2</sub> O <sub>3</sub>	0	0.5	1	1.5	0.5	1	1.5	0.5	1	1.5	0	0	0	0	0	0	0	0	0
(%)																			
CaCo <sub>3</sub>	0	0	0	0	0	0	0	0	0	0	0.5	1	2	0.5	1	2	0.5	1	2
(%)																			

TABLE.5 Cube ID of different cube specimen

1) compressive Strength Test Result of fly Ash And Nano fe 203 Containing Concrete Cubes.

			1	U		2			
CUBE ID	C1	$C_2$	C <sub>3</sub>	$C_4$	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>
Compressive	26.10	28.15	26.25	22.15	23.26	22.15	20.15	21.80	22.64
Strength									
(MPa)7 days									
Compressive									
Strength	34.70	39.70	35.26	32.42	37.46	35.70	30.20	34.25	31.40
(MPa) 28									
days									
									l

TABLE.6 Compressive Strength of Concrete with Fly Ash and Nnano Fe  $_2O_3$ 



Fig.1 Compressive strength of concrete with fly ash and nano Fe  $_2O_3$ 



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2) Compressive Strength Test Result of fly Ash And Nano Caco<sub>3</sub> Containing Concrete Cubes.

CUBE ID	C <sub>10</sub>	C11	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C15	C <sub>16</sub>	C <sub>17</sub>	C <sub>18</sub>
7 days	23.75	26.18	22.12	21.15	30.42	20.24	19.80	22.65	22.90
Compressive									
Strength									
(MPa)									
28 days	36.15	39.15	34.20	34.65	40.25	32.10	31.20	37.25	32.10
Compressive									
Strength									
(Mpa)									

TABLE.7 Compressive strength of concrete with fly ash and nano CaCo<sub>3</sub>



Fig. 2 Compressive strength of concrete with fly ash and nano CaCo<sub>3</sub>

*3)* Compressive Strength Test Result of Fly ash And Both Nano Caco<sub>3 and</sub> Nano fe<sub>2</sub>o<sub>3</sub> Containing Concrete Cubes.

The Optimum % of fly ash is decided as 30 % and Nano  $Fe_2O_3$  and  $CaCo_3$  are 1 %. The cube ID of the optimum % contained cube is  $O_1$ . The cube ID of the control specimen is  $C_0$ . The optimum specimen and control specimen results are given below.

TABLE.8	Compressive	Strength of	Control Specimen and	d Concrete Specimen	with Fly Ash,	Nano Fe <sub>2</sub> O <sub>3</sub> and CaCo <sub>3</sub>
		U	1	1		

CUBE ID	C <sub>0</sub> (Control specimen)	O <sub>1</sub> (optimum specimen)
7 days Compressive	19.85	22.34
Strength (MPa)		
28 days	32.15	38.84
Compressive Strength		
(MPa)		



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# B. Flexural Strength Test Results

In the flexural strength test the 150mm×150mm×700mm size beam (when size of aggregate is less than 38mm)or 100mm×100mm×500mm size beam (when size of aggregate is less than 19mm) specimen are used. The bed of the flexural test machine shall be provided with tow steel rollers,38 mm in diameter, on which the specimen is to be supported ,and these rollers shall be so mounted that the distance from center to center is 60 cm for 15 cm specimens or 40 cm for 10 cm specimens. The load shall be applied at a rate of loading of 400 kg/min for the 15 cm specimen and at a rate of 180 kg/min for the 10 cm specimen.

TABLE.9 Flexural Strength of Control Specimen and Concrete Specimen with Fly Ash, Nano Fe<sub>2</sub>O<sub>3</sub> and CaCo<sub>3</sub>

BEAM ID	B <sub>0</sub> (Control specimen)	B <sub>1</sub> (optimum specimen)
7 days Flexural Strength	6.30	6.92
(MPa)		
28 days	8.04	8.42
Flexural Strength (MPa)		

# C. Splite Tensile Strength Test Results

Splitting tensile strength test on concrete cylinder size 150mm Dia. $\times$ 300mm Height is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile force. Apply the load continuously without shock at a rate of approximately 14-21 kg/cm<sup>2</sup> per minute(which corresponds to a total load of 9900kg/minute to 14850 kg/minute). Note down the breaking point.

TABLE 10 Splite Tensile	Strength of Cor	trol Specimen and	l Concrete Specimen	with Fly Ash	Nano Fe <sub>2</sub> O <sub>2</sub> and C	<sup>a</sup> Co <sup>2</sup>
TADLE. TO Splite Tensile	Suchgui of Col	and specificit and	i Concrete Speemien	with Try Ash	1, 10 i $0, 0, 0, 3$ and $0$	<i>a</i> co <sub>3</sub>

CYLINDER ID	CY <sub>0</sub> (Control specimen)	CY <sub>1</sub> (optimum specimen)
7 days Spite Tensile	2.1	2.32
Strength (MPa)		
28 days	2.68	2.81
Spite Tensile Strength		
(MPa)		

# D. Durability Test Results

1) Chloride Resistance Test : Cubes of 150mm×150mm×150mm dimension were casting and have cured for 28 days. After 28 days curing cubes were taken out and allowed for drying for 24 hours and weight were taken. For chloride attack test 5% dilute NaCl is used. The cubes were to be immersed in solution for a period of 56days. The concentration is to be maintained throughout this period. After 30 days the specimens were taken from acid solution. The surface of specimen has cleaned and weights were measured. The specimen was tested in the compression testing machine under a uniform rate of loading 140 kg/cm<sup>2</sup> as per IS 516. The loss of mass and loss of strength of specimen due to chloride attack was determined..

TABLE.11 NaCl Solution for 56 days

Concrete specimen	Loss of weight in %	Loss of Comp. Strength in %	
Control specimen	1.98	2.61	
Optimum specimen	1.95	2.54	

2) Carbonation Test: In the carbonation test the concrete cube are casted and after 90 days to sprayed a phenolphthalein solution on the cube and to see the color of the cube. when the color are changed a pink color so the carbonation are not occur, and when the color are not changed then the carbonation are occured. In these experiment the color of concrete are changed and pink color are occurred so the carbonation effect are not in the concrete.



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## V. CONCLUSION

In this study the effect of nano Fe  $_2O_3$  and fly ash are study and the effect of nano CaCo<sub>3</sub> and the fly ash are study. According to these study to determined the optimum % of fly ash, nano CaCo<sub>3</sub>, nano Fe  $_2O_3$  and to determined the tertiary effect of fly ash, nano CaCo<sub>3</sub>, and nano Fe  $_2O_3$  on the concrete and to compare the normal concrete.

- *A*. We concluded that the maximum compressive strength are occure at the 1 % CaCo<sub>3</sub> and 30 % fly ash. The compressive strength is 40.25 MPa at 28 days.
- *B.* We concluded that the maximum compressive strength are occure at the 1 % Fe  $_2O_3$  and 25 % fly ash. The compressive strength is 40.25 MPa at 28 days.
- *C*. For check out the tertiary effect of the fly ash, nano Fe  $_2O_3$  and nano CaCo<sub>3</sub> the optimum % of nano Fe  $_2O_3$  and nano CaCo<sub>3</sub> are taken as 1% and fly ash is 30%. In the optimum specimen the strength of the optimum specimen is 38.84 MPa at 28 Days and the compressive strength of normal concrete is 32.15 MPa at 28 days.
- D. The flexural strength and the split tensile strength are good with compared to the normal concrete.
- E. There is no carbonation effect on the concrete. to provide a durable concrete in these study.

#### REFFERENCES

- Ali Nazari, Shadi Riahi, Shirin Riahi, Seyedeh Fatemeh Shamekhi and A. Khademno; "Benefits of Fe2O3 nanoparticles in concrete mixing matrix", Journal of American Science, Fe<sub>2</sub>O<sub>3</sub> Nanoparticles in Concrete 6(4)(2010)102-106
- Xiaoyan Liu, Lei Chen, Aihua Liu, Xinrui Wang "Effect of Nano-CaCO3 on Properties of Cement Paste", Science Direct, Energy Procedia 16(2012)991-996.
- [3] Meral Oltulu, Remzi S, ahin 'Effect of nano-SiO2, nano-Al2O3 and nano-Fe2O3 powders on compressive strengths and capillary water absorption of cement mortar containing fly ash: A comparative study'', Elsevier, Energy and Building 58(2013)292-301.
- [4] particles''Faiz U.A. Shaikh, Steve W.M. Supit ''Mechanical and durability properties of high volume fly ash (HVFA) concrete containing calcium carbonate (CaCO3) nano particles'', Elsevier, Construction and Building Materials 709(2014)309-321.
- [5] Hamid Soltanian, Reza Khalokakaie, Mohammad Ataei, Ezatallah Kazemzadeh "Fe2O3 nanoparticles improve the physical properties of heavy-weight wellbore cements: A laboratory study", Elsevier, Journal of Natural Gas Science and Engineering 26(2015)695-701.
- [6] Mohamed Amin , Khaled Abu el-hassan " Effect of using different types of nano materials on mechanical properties of high strength concrete", Elsevier, Construction and Building Materials 80(2015)116-124.
- [7] E. Gerasimova "The Effect of Fe2O3 on the Mechanical Properties of the Polymer Modified Cement Containing Fly Ash", Science Direct, Procedia Engineering 150(2016)1553-1557.
- [8] Mariana O.G.P. Bragança, Kleber F. Portella, Marcelle M. Bonato, Emerson Alberti, Cláudia E. B. Marino "Performance of Portland cement concretes with 1% nano-Fe3O4 addition: Electrochemical stability under chloride and sulfate environments", Elsevier, Construction and Building Material 117(2016)152-162.
- [9] Rattan a; Sachdeva P ; Chaudhary A "Use of nano materials in concrete" ,IJLRET(2016)81-84.
- [10] Kalpana Kumaria, R.Preethaa, D. Ramachandranb, Vinita Vishwakarmab, Rani.P.Georgec, C.Sundaramurthya,U.Kamachi Mudalic, C. Sivathanu Pillaia "Nanoparticles for enhancing mechanical properties of fly ash concrete" Elsevier, Material Today; Proceedings 3(2016)2387-2393,.
- [11] Tao Meng, Yejia Qiang, Anfeng Hu, Chuntai Xu, Lei Lin "Effect of compound nano-CaCO3 addition on strength development and microstructure of cementstabilized soil in the marine environment", Elsevier, Consruction and Building Material 151(2017)775-781.
- [12] Dixit b. Patel, Dr.D.J. Varia, DR.K.G. Mehta "Review On Experimental Comparative Study By Using Nano CaCo<sub>3</sub> And Nano Fe<sub>2</sub>O<sub>3</sub> In Fly Ash Containing Concrete "IJRASET, (2018).
- [13] IS:2386-1963 (Part-III). Methods of Test for aggregates for concrete Part III specific gravity, density, voids, Absorption and bulking. Bureau of Indian Standards.
- [14] IS:383-1970. Specification for coarse aggregate and fine aggregate from natural sources for concrete. Bureau of Indian Standards.
- [15] IS:456-2000. Plain and Reinforced concrete- code of practice (FourthRevision).Bureau of Indian Standards.
- [16] IS: 3812-1981, Specification for Fly Ash for use as pozzolana and admixture
- [17] IS: 10262-2009 Concrete Mix Proportioning Guidelines
- [18] IS:12269-2013. Ordinary Portland Cement 53 Grade Specification .

#### A. Book and Sources

- [1] Properties of Concrete By: A. M. Nevile
- [2] Concrete Technology; Theory And Practice; M.S.SHETTY;S Chand Publication.
- [3] <u>www.sciencedirect.com</u>
- [4] www.elsevier,com











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