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STUDY ON PERFORMANCE OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND INCLUDATION OF NANO MATERIAL

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ABSTRACT

Concrete, the most ubiquitous material in the world, is a nano structured, multi-phase, composite materials that ages overtime. It is composed of an amorphous phase, nanometre to micrometre size crystals, and bound water. The infused nanoparticles within a concrete known as Nano concrete, has been an unindustrialized area of research that is yet to be commercialized. These exorbitant materials are still in progress of having their prices reduced through different sustainable production to get their way into the concrete industry as sustainable, durable and economical material. The importance of the incorporation of nanomaterials in concrete has emerged as a promising research interest due to the outstanding functionalized properties of the materials at that size level. This study aims to investigate the change in compressive strength as well as flexural strength of the concrete after the addition of hybrid nanomaterials. Different scholarly articles have carried out the experiments and the test results show enormous and outrageous changes in the mechanical properties. It has been identified that the utilization of nanomaterials as a partial substitute for binder or as a filler material in cement concrete modifies the rheology and the microstructure at the nano scale, significantly improving the mechanicals and durability characteristics of cementitious composites. This paper deals with only four kinds of nano materials: Nano-Silica, Multi walled Carbon Nanotubes, Nano Graphene Oxide & Fly Ash. Concrete with water-cement ratio of 0.40 is used with paste content and the proportions are fixed using IS CODE 10262:2019 method containing different percentages of nanomaterials. A number of tests will be carried out on 100 mm^3 concrete cubes is used for flexural tests. Investigation shows that the addition of nanomaterials has a significant effect on the physical and mechanical properties of concrete. The compressive strength & flexural strength both will be increased, the strength of the concrete depends on the percentages of nanomaterials, increment causes decrease in strength. Increase in the ages of concrete, increase the strength of the concrete. As compared with ordinary concrete, nano concrete exhibit greater performance. This research paper is a trial given some highlight for the introduction of nanomaterials in various types of concrete.

Keywords: Nanomaterials, Nano Silica, Multi Walled Carbon Nanotubes, Nanographene Oxide, Fly Ash.

I. INTRODUCTION

Nanotechnology is the science and engineering at the scale of atoms and molecules. It is the manipulation and use of materials and devices so tiny that nothing can be built any smaller. Nanomaterials are typically between 0.1 and 100 nanometre (nm) in size with 1 nm being equivalent to one billionth of a metre (10^{-9} m) ,this is the scale at which the basic functions of the biological world operate and materials of this size display unusual physical and chemical properties. These profound different properties are due to an increase in surface area compared to volume as particles get smaller. The concept of nanotechnology was originally introduced by the famous physicist Richard Feynman in 1959, through his talk "There's Plenty of Room at the Bottom", which he delivered to an American Physical society meeting at the California Institute of Technology. In the lecture, he discussed the possibility of using atoms as building particles to create nano sized products. The ideas put forward by Feynman passed unnoticed until 1974 when Norio Taniguchi introduced the word "nanotechnology" at the International Conference on production Engineering. Taniguchi described the processes of creating semiconductor structures using various methods with nanometre precision. He introduced the "top-down" approach, which refers to the successive cutting or slicing of a bulk material to create nano sized particles. In 1986 Kim Eric Drexler developed the idea of nanotechnology and published a book titled "Engines of Creation: The coming Era of Nanotechnology" . In the book, he proposed the idea of a nanoscale assembler, which would have the capacity and ability to build the copies of itself and other things of

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distinctive complexity, known as molecular nanotechnology (MNT). Today, nanotechnology offers potential opportunities to create better materials with enhanced properties for use in various application areas. Particular relevance for concrete is the greatly increase surface area of the particles at the Nano scale. As the surface area mass of a material increases, a greater amount of the material can come into contact with surrounding materials, thus affecting reactivity. If cement with nano-size particles can manufactured and processed, it will open up a large nanotechnology working field. Currently cement composite is most widely used material in concrete structures. Although cementitious composites are high in compressive strength, it has disadvantages such as low tensile & flexural strength & also high cracking tendency. As hardened cement paste consists of such as nano silica, carbon nano tubes. As cement composite exhibits porous nature due to lack of bonding between crystal structures in the cementitious mixture, the porosity in cementitious material plays a major role. Due to the size & structure of pores, it can affect the mechanical properties, fluid diffusion characteristics & durability of material. It is well-known that, Nano materials show excellent physical & Chemical characteristics which improves effectiveness of materials. As nano materials have small particle sizes, large specific surface areas, and strong interface interactions with the cement mix. they are easy to be merged with cement to prepare cement base nanocomposites and thus enhances the mechanical performance and service life. Add to this, nano inundations help to reduce the cement dosage. Different type of nano materials such as nano silica, carbon nano tubes, nano Titanium oxide, Nano Graphene Oxide are used to reinforce the cement matrix. There is a paradigm shift towards developing Nano Graphene based nano cement composites due to high performance characteristics in cement concrete. When Cement replaced by fly ash of different percentage, the strength should be different. Fly ash is a pozzolanic materials, because of their reaction with lime (Calcium hydroxide) liberated during the hydration of Cement.

II. OBJECT OF STUDY

In nanotechnology field, we can use nano materials which are binder materials or filler materials. When we use nano material to upgrade the strength of concrete, we choose different types of nanomaterials like Nano Silica, Nano Graphene Oxide, Multi walled Carbon Nanotubes, Micro Silica, Steel Fibres & Fly Ash ect..When coarse aggregate and fine aggregate mixed with a particular proportions with Cement and portable water, the concrete strength should be vary. If we can fixed the nanomaterials proportions and replace the Cement mass with Fly ash, the concrete strength differ from one stage to another stage. If we replace Cement mass with the fly ash, the production cast must be decrease. At the same time if the voids in the concrete is filled by nanomaterials, the strength of the concrete must be increase. Because the surface area of nanomaterials is higher than the other materials. The reaction area is higher than the other materials.

- To investigate the impact of Fly Ash, Nano Graphene Oxide, MWCNT, Nano silica on Concrete Strength.
- To study the fresh state and hardened stat properties of M30 with 0.3 % Nano material as partial replacement of cement by Fly Ash.
- To study the fresh state and hardened state of M30 with 60 % Fly Ash as partial replacement of cement by fly ash.
- To explain any changes in concrete characteristics, if any by describing the concrete.
- To investigate different basic properties of concrete such as compressive Strength, splitting tensile strength.

III. LITERATURE REVIEW

Abhinayaa (2014)[1] investigated and understood that the increasing the proportions of functionalized MWCNT into concrete increases the compressive strength. In fact the compressive strength of the concrete with a proportion of 0.045% of functionalized MWCNT increases by 26.69%. the split tensile strength increased by 66.3% for 0.045% of MWCNT. With increase in MWCNT, the rate of increase of the tensile strength is greater than that of the rate of increase of the compressive strength.

Coppola (2011)[2] investigated about cement pastes reinforced with MWNTs are smart materials with piezo resistivity properties. MWNTs were dispersed in a surfactant (Sodium Linear Alkyl Benzene Sulphonate – LAS), and then mixed with cement and a defoamer (tributyl phosphate) to decrease the air bubble in MWNT filled cement-based composites. These findings seems to indicate that self-sensing CNTs/cement composites can be produced. These smart materials (Concrete with CNT) have great potential and they could be used in the next future in concrete field for practical applications to monitor stress level of reinforced concrete elements subjected to static, dynamic and impact loads.

Sudipta Naskar (2016)[3] has taken up an experimental program on low calcium fly-ash based M25 grade geopolymer concrete having 16 (M) concentration of activator liquid. Different percentage of nano materials viz. nano silica, carbon nanotube, titanium di-oxide were also used to investigate the effect of nano materials on geopolymer concrete. Geopolymer concrete with 1% of titanium di-oxide shows appreciable improvement in compressive strength.pH maintained almost same in all cases.

Tanzir Manzur [4] has done a parametric experimental investigation to determine optimum mix dosage of CNT for cement mortar. Different dosage rates of surface treated MWCNTs, water-cement ratios and plasticizers amounts were investigated through compressive and flexural strength determination. A mixing technique was proposed to address the issues related to dispersion of nanotubes within cement matrix. Both enhances the strength compared to control samples with no MWCNTs.

K. Habermehl C wirzen (2008)[5] found that the increase in the compressive strength is nearly 38% to 50% even with only a small addition of the MWCNTs, namely 0.045-0.15% of the cement weight. Highest increase in the compressive strength was nearly 50% in cement paste incorporating only 0.045% of the polyacrylic acid polymer-treated MWCNTs.

Maheswaran S. (2013) [6] discussed about the influence of nanosilica along with cement, cement mortars, concretes and supplementary cementitious materials. The changes in the microstructure of cement by pore filling effect of nanosilica in the concrete. Different journals are analysed and influence of nanosilica with different dosages are studied. It has been concluded that enhancement of concrete is observed in delay of microcrack development ,pore filling effects, reduction of CH leaching, rheological behavior of cement paste, heat of hydration, the pozzolonic activity, workability, strength and durability.

Wijdan Deyaa (2017)[7] deals with the impact of Nano-concrete on contemporary architecture explaining about the nano concrete mixes different from the ordinary mixes of concrete, the applications in the buildings and its effect.

B.B.Das (2014)[8] has explained about all the types of nanomaterials used for construction purposes such as carbon nanotubes, nano clays, nano flex, nanowires, nanoceramic coating, nano silica, nanocrystalline materials, etc. The properties and applications have been highlighted so that the readers can get the brief overview of the nanomaterials, considering the design of sustainable and durable structures.

Karla P. Bautisla-Gutierrez (2019) [9] highlighted the change in physical and chemical properties of concrete. Addition of nanomaterials in cement-based materials bring out microstructural development. Nano silica, nano-ferric oxide, nano titanium oxide, nano-alumina and grapheme- based nanomaterials are explained through SEM images. Incorporating variable percentages of different nano-materials, microstructural changes are shown precisely. Different tests such as compressive strength tests and flexural strength tests are shown using different percentage content of nanomaterials. Comparative bar graphs are also represented. Few challenges have been discussed with some approximate needful way of development.

V. Sai. Kiran (2016)[10] has shown experimental method and compares the mechanical properties of nano concrete to that of high strength of concrete. The compressive strength test, split tensile strength test and bond strength test have done to show the differences of the mechanical properties. It has been found that the performance of nano concrete is much better than control concrete.

Vishutosh Bajpai (2018) [11] shows the study regarding the effect of nano silica on the compressive strength, workability and the microstructure of the hardened cement concrete. Up to 3% nano silica is replaced showing maximum result on 2.5% replacement in compressive strength test and tensile strength test. It has been concluded that even a small amount of nano silica particles can increase the strength of concrete.

Dr. B. Vidivelli (2018) [12] discuss about the physical, mechanical, thermal, electrical and electronics properties of single wall carbon nano tubes (SWCNT) and multi-wall carbon nanotubes (MWCNT). It has been concluded that addition of small amounts of CNT can improve the mechanical properties of samples consisting of the main Portland cement phase and water. Oxidized multi-walled carbon nanotubes show the best improvements both in compressive strength and flexural strength compared to the sample without reinforcement.

Syed Nooruddin [13] incorporated 1%, 2%, 3% and 3.5% of nano silica by weight of cement. Throught experiment it has been observed that the compressive strength of concrete initially increased up to 3% nano silica and with further increase in the nano silica content the compressive strength of content decreases. The permeability of concrete decreases with the increase in percentage of nano silica up to 3% due to the effect of nano silica filling the voids in concrete. Use of nano silica in the concrete reduces the CO2 emission.

Mani. M (2017) [14] carried out a review about nanomaterials such as nano silica, nano titanium dioxide and carbon nanotubes. Analysis of different papers and conclusion drawn shows the factual features of nano concrete.

IV. MATERIALS

4.1 Multi Walled Carbon Nanotubes

Carbon nanotubes are seamless, carbon cylinders which have unique mechanical and properties. Carbon nanotubes are a form of carbon having a cylindrical shape, the name coming from their nanometre diameter. they can be several millimetres in length and can have one layer or wall & multi -walled. Nanotubes are members of the fullerene structural family and exhibit extraordinary strength and unique electrical properties, being efficient thermal conductors. For example, they have five times the Young's modulus and eight times the strength of steel, whilst being 1/6 th the density. Expected benefits of carbon nanotubes are: mechanical durability and crack prevention in concrete enhanced mechanical and thermal properties in ceramics and real-time structural health monitoring capacity.

4.2 Nano Silica

Nano-Silica could significantly increase the compressive strength of concretes containing large fly ash volume at early age, by filling the pores between fly ash and cement particles. Nano-silica decreases the setting time of mortar when compared with silica fume and reduce bleeding water and segregation by the improvement of the cohesiveness. The use of nano silica in concrete mix has shown results of increase in the compressive, tensile and flexural strength of concrete. It sets early and hence generally requires admixtures during mix design. Nano Silica mixed cement can generate nano crystals of C-S-H gel after hydration. These nano-crystals accommodate in the micro pores of the cement concrete, hence improving the permeability and strength of concrete. Strength also improved after 3 days up to 6%.

4.3 Nano Graphene Oxide

Graphene oxide is a unique material with various oxygen containing functionalities such as epoxide, carbonyl and hydroxyl groups. It is one of the prominent Nano material, this has been utilized in producing cement composite materials. It represents unique range properties likes to enhance the strength and durability properties of the fresh and hardened cement concrete. Compressive strength, split tensile strength and flexural strength tests were conducted to the hardened graphene oxide base concrete at 7days,14days and 28 days. Graphene Oxide addition increases the viscosity, decreases the fluidity of concrete.

4.4 Cement

In this experimental study, 53 grade Ordinary Portland Cement (OPC) conforming to IS 12269:1987 was used. The specific gravity of the cement was 3.12 and its specific surface area was 345 m^2 /g. It is a binder, substance used in construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used solely, but is used to bind sand and aggregate together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete.

$2C_3S+6H = C_3S_2H_3+3CH$

$2C_2S+4H = C_3S_2H_3+CH$

Cement Chemistry notation: C = Cao; S= Sio_2; H = H_2O

With reference to the above equation, it is learnt that the C-S-H is the strength phase, whereas the by product, CH is not having any cementitious properties, easily to leached out, prone to Chemical attack.

4.5 Water

Fresh potable water, which is free from acid and organic substances, was used in making and curing of the concretes.

4.6 Chemical admixture

Super Plasticizers:- Super Plasticizers ,also known as high range water reducers, are the chemical used as admixtures where well-dispersed particle suspensions are required . These are used as dispersants to avoid particle aggregation and to improve the flow Characteristics of such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. The admixture which was used only Nano concrete to provide necessary workability was a fourth generation super plasticizer.

4.7 Fly Ash

Fly ash is a heterogenous by product materials produced from Kola Ghat Thermal power Station, West Bengal India. Addition of fly ash particles in Graphene Oxide based concrete adds workability. Added to this, fly ash particles contribute towards pozzolanic reaction to improve the performance of concrete. Fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm.

SiO_2, Al_2O_3, Fe_2O_3 and occasionally CaO are the main chemical components present in fly ashes. Two classes of fly ash are defined by American Society for Testing and materials (ASTM) C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned.

V. RESULT & DISCUSSION

5.1. CONVENTIONAL CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH:-

5.1.1. COMPRESSIVE STRENGTH:-

In IS 10262:2019 method, the ratio of cement, fly ash, fine aggregate and coarse aggregate is found out. Taking various content, the amount of materials are calculated. Moulds each of 7days, 14days and 28 days compressive strength are made. Following table shows the observation value of the compressive strength test:

Table 5.1: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash

SL.NO.	Sample Numbers	Different Percentage of Cement	Different Percentage of Fly Ash	Compressive Strength (N/mm^2)			Average Compressive Strength(N/mm^2)
				7 Days	14 Days	28 Days	
1.	(C1) Sample1 Sample2 Sample3	70 % 70 % 70%	30 % 30 % 30 %	17.89 17.85 17.92	26.15 26.05 26.10	29.05 28.95 28.97	7 days-17.89 14 days-26.10 28 days-28.99
2.	(C 2) Sample1 Sample2 Sample3	65 % 65 % 65 %	35 % 35 % 35 %	16.54 16.65 16.55	25.25 25.31 25.18	28.05 28.10 27.98	7 days-16.58 14 days – 25.25 28 days-28.04
3.	(C3) Sample1 Sample2 Sample3	60 % 60 % 60 %	40 % 40 % 40 %	15.86 15.58 15.62	24.73 24.70 24.72	27.45 27.34 27.38	7 days-15.67 14 days-24.72 28 days-27.39
4.	(C4) Sample1	55 % 55 %	45 % 45 %	14.87 14.85	23.75 23.95	26.35 26.25	7 days-14.82 14 days-23.85

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	Sample2 **Sample3**	55 %	45 %	14.75	23.85	26.15	28 days-26.25
5.	**(C5)** **Sample1** **Sample2** **Sample3**	50 % 50 % 50 %	50 % 50 % 50 %	12.66 12.78 12.75	21.95 22.05 22.25	25.25 25.23 25.45	7 days-12.73 14 days-22.08 28 days-25.31
6.	**(C6)** **Sample1** **Sample2** **Sample3**	45 % 45 % 45 %	55 % 55 % 55 %	10.95 11.05 11.15	14.05 14.25 14.15	15.65 15.85 15.75	7 days-11.05 14 days-14.15 28 days-15.75
7.	**(C7)** **Sample1** **Sample2** **Sample3**	40 % 40 % 40 %	60 % 60 % 60 %	8.80 8.95 8.82	11.99 11.95 11.97	13.35 13.45 13.42	7 days-8.86 14 days-11.97 28 days-13.41

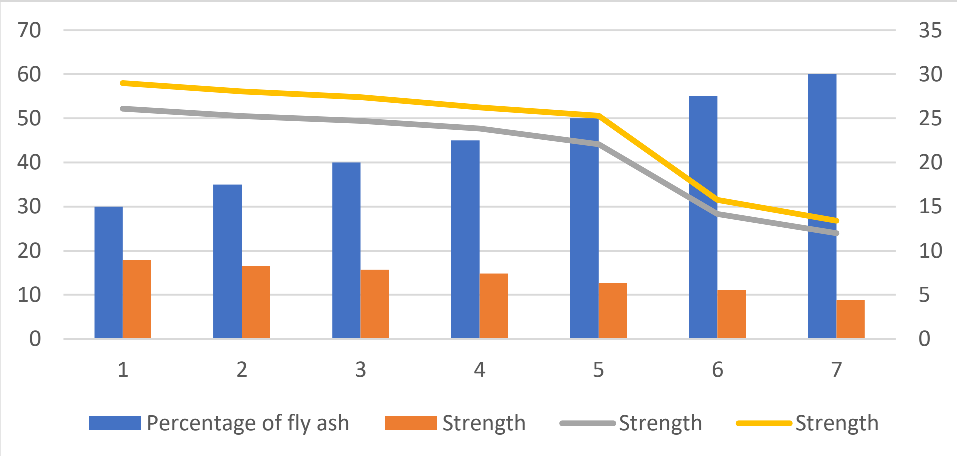

Fig.5.1. Conventional Concrete By Partial Replacement Of Cement With Fly Ash

Table 5.2: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash & 0.3 % Multi Walled Carbon Nanotubes.

SL.NO.		**Different Percentage of Cement**	**Different Percentage of Fly Ash**	**Compressive Strength (N/mm^2)**			**Average Compressive Strength(N/mm^2)**
				7 Days	**14 Days**	**28 Days**	
1.	**(C1)** **Sample1** **Sample2** **Sample3**	70 % 70 % 70%	29.991 % 29.991 % 29.991 %	23.93 23.91 23.92	32.95 33.08 32.97	36.79 36.77 36.81	7 days-23.92 14 days-33.00 28 days-36.79
2.	**(C 2)** **Sample1** **Sample2** **Sample3**	65 % 65 % 65 %	34.895 % 34.895 % 34.895 %	22.57 22.59 22.62	31.30 31.32 31.34	34.76 34.78 34.80	7 days-22.59 14 days – 31.32 28 days-34.78
3.	**(C3)** **Sample1** **Sample2**	60 % 60 % 60 %	39.88 % 39.88 % 39.88 %	20.86 20.82 20.79	28.95 28.80 28.78	32.79 32.75	7 days-20.82 14 days-28.84 28 days-32.76

	Sample3					32.73	
4.	**(C4)** **Sample1** **Sample2** **Sample3**	55 % 55 % 55 %	44.865 % 44.865 % 44.865 %	19.85 19.80 19.75	27.75 27.65 27.85	30.76 30.70 30.74	7 days-19.80 14 days-27.75 28 days-30.73
5.	**(C5)** **Sample1** **Sample2** **Sample3**	50 % 50 % 50 %	49.85 % 49.85 % 49.85 %	18.56 18.58 18.60	25.64 25.62 25.62	28.51 28.48 28.50	7 days-18.58 14 days-25.63 28 days-28.50
6.	**(C6)** **Sample1** **Sample2** **Sample3**	45 % 45 % 45 %	54.835 % 54.835 % 54.835 %	17.19 17.21 17.20	23.80 23.82 23.83	26.43 26.46 26.44	7 days-17.20 14 days-23.82 28 days-26.44
7.	**(C7)** **Sample1** **Sample2** **Sample3**	40 % 40 % 40 %	59.82 % 59.82 % 59.82 %	15.92 15.95 15.94	21.99 21.95 21.97	24.39 24.38 24.41	7 days-15.94 14 days-21.97 28 days-24.39

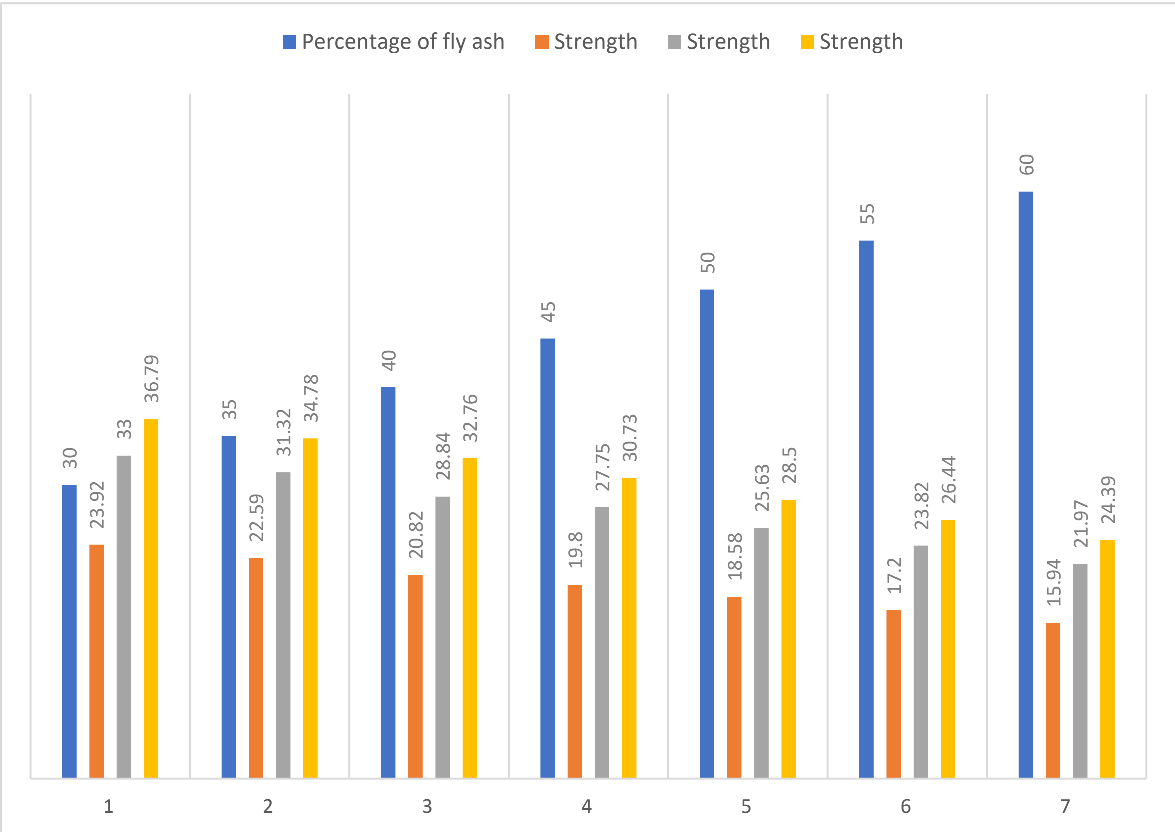

Fig 5.2: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash & 0.3 % Multi Walled Carbon Nanotubes.

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Table 5.3: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash & 0.3 % Graphene Oxide.

SL.NO.		Different Percentage of Cement	Different Percentage of Fly Ash	Compressive Strength (N/mm^2)			Average Compressive Strength(N/mm^2)
				7 Days	14 Days	28 Days	
1.	**(C1)** **Sample1** **Sample2** **Sample3**	70 % 70 % 70%	29.991 % 29.991 % 29.991 %	21.23 21.21 21.24	29.37 29.39 29.36	32.64 32.66 32.65	7 days-21.23 14 days-29.37 28 days-32.65
2.	**(C 2)** **Sample1** **Sample2** **Sample3**	65 % 65 % 65 %	34.895 % 34.895 % 34.895 %	20.07 20.08 20.06	27.78 27.79 27.76	30.86 30.88 30.85	7 days-20.07 14 days – 27.78 28 days-30.86
3.	**(C3)** **Sample1** **Sample2** **Sample3**	60 % 60 % 60 %	39.88 % 39.88 % 39.88 %	18.89 18.86 18.87	26.11 26.15 26.14	29.03 29.01 29.02	7 days-18.87 14 days-26.13 28 days-29.02
4.	**(C4)** **Sample1** **Sample2** **Sample3**	55 % 55 % 55 %	44.865 % 44.865 % 44.865 %	17.75 17.70 17.65	24.57 24.56 24.55	27.31 27.30 27.32	7 days-17.70 14 days-24.56 28 days-27.31
5.	**(C5)** **Sample1** **Sample2** **Sample3**	50 % 50 % 50 %	49.85 % 49.85 % 49.85 %	16.32 16.30 16.31	22.55 22.57 22.58	25.08 25.05 25.09	7 days-16.31 14 days-22.57 28 days-25.07
6.	**(C6)** **Sample1** **Sample2** **Sample3**	45 % 45 % 45 %	54.835 % 54.835 % 54.835 %	15.52 15.50 15.51	21.47 21.46 21.48	23.84 23.87 23.85	7 days-15.21 14 days-21.47 28 days-23.85
7.	**(C7)** **Sample1** **Sample2** **Sample3**	40 % 40 % 40 %	59.82 % 59.82 % 59.82 %	14.09 14.07 14.08	19.49 19.50 19.51	21.65 21.68 21.66	7 days-14.08 14 days-19.50 28 days-21.66

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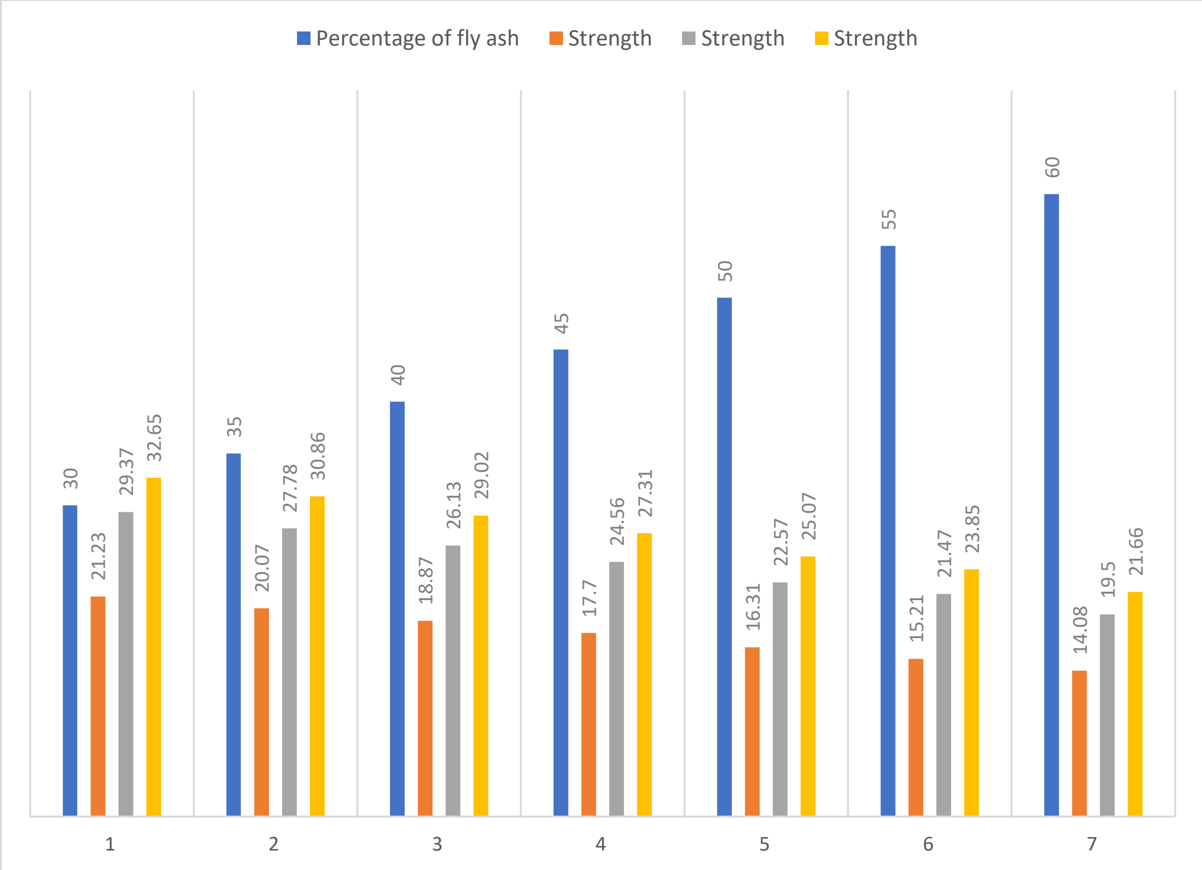


Fig 5.3: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash & 0.3 % Graphene Oxide.

Table 5.4: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash & 0.3 % Nano Silica.

SL.NO.		Different Percentage of Cement	Different Percentage of Fly Ash	Compressive Strength (N/mm^2)			Average Compressive Strength(N/mm^2)
				7 Days	14 Days	28 Days	
1.	**(C1)** **Sample1** **Sample2** **Sample3**	70 % 70 % 70%	29.991 % 29.991 % 29.991 %	19.40 19.42 19.40	27.87 27.85 27.86	29.86 29.85 29.87	7 days-19.41 14 days-27.86 28 days-29.86
2.	**(C 2)** **Sample1** **Sample2** **Sample3**	65 % 65 % 65 %	34.895 % 34.895 % 34.895 %	18.23 18.20 18.22	25.24 25.25 25.27	28.00 27.95 28.05	7 days-18.22 14 days – 25.25 28 days-28.00
3.	**(C3)** **Sample1** **Sample2** **Sample3**	60 % 60 % 60 %	39.88 % 39.88 % 39.88 %	16.98 16.96 16.95	23.52 23.55 23.54	26.17 26.15 26.18	7 days-16.96 14 days-23.54 28 days-26.17
4.	**(C4)** **Sample1** **Sample2**	55 % 55 % 55 %	44.865 % 44.865 % 44.865 %	15.99 15.98 15.97	22.15 22.14 22.17	24.60 24.62 24.64	7 days-15.98 14 days-22.15 28 days-24.62

	Sample3						
5.	**(C5)** **Sample1** **Sample2** **Sample3**	50 % 50 % 50 %	49.85 % 49.85 % 49.85 %	15.05 15.06 15.04	20.83 20.84 20.85	23.18 23.15 23.17	7 days-15.06 14 days-20.84 28 days-23.17
6.	**(C6)** **Sample1** **Sample2** **Sample3**	45 % 45 % 45 %	54.835 % 54.835 % 54.835 %	13.89 13.87 13.88	19.23 19.20 19.22	21.35 21.33 21.36	7 days-13.88 14 days-19.22 28 days-21.35
7.	**(C7)** **Sample1** **Sample2** **Sample3**	40 % 40 % 40 %	59.82 % 59.82 % 59.82 %	12.36 12.38 12.35	17.15 17.17 17.19	19.08 19.05 19.07	7 days-12.36 14 days-17.17 28 days-19.06

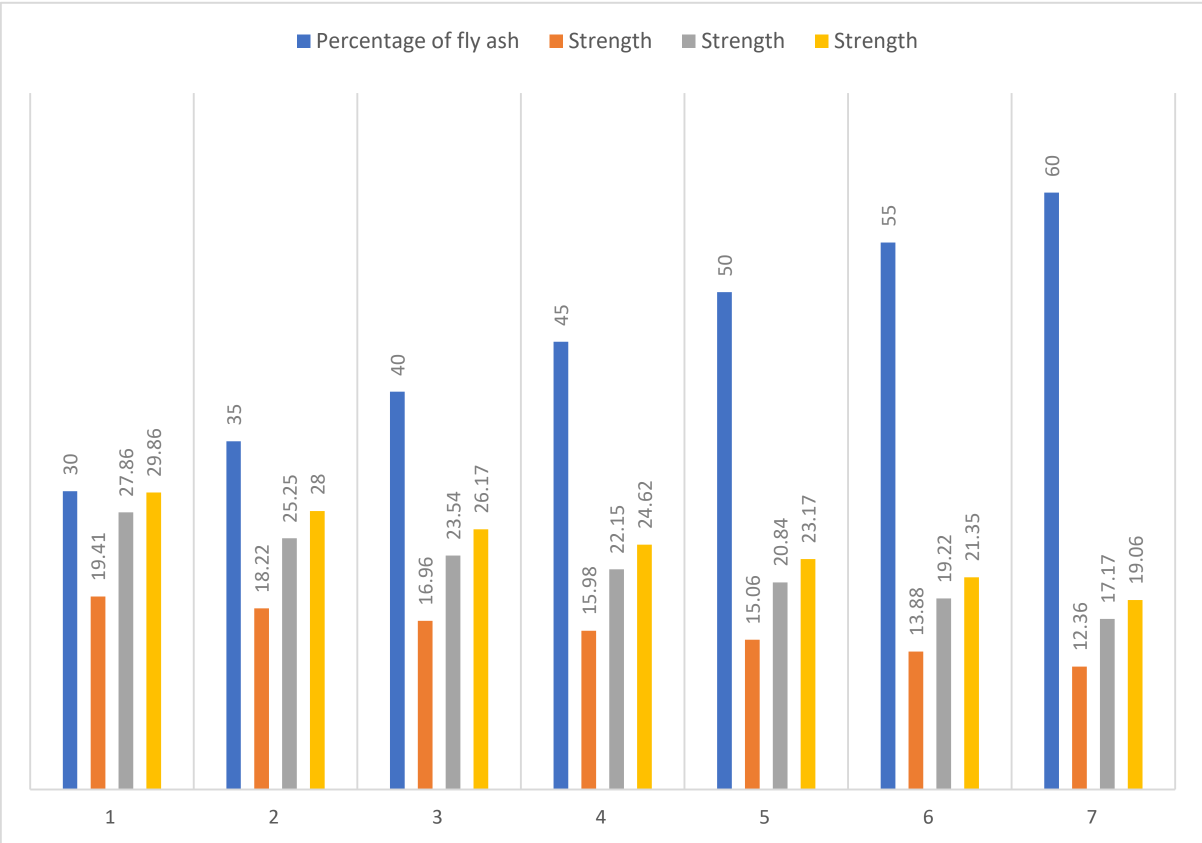


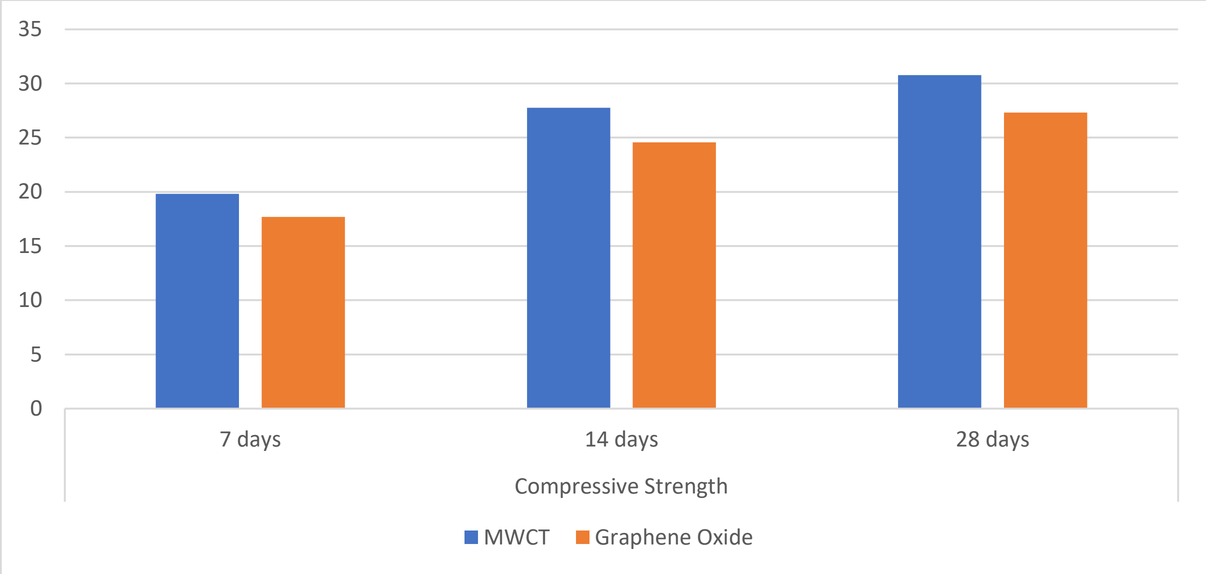
Fig 5.4: Compressive Strength of Conventional Concrete by partial replacement of Cement with Fly Ash & 0.3 % Nano Silica.

5.2. DISCUSSIONS:-

This thesis describes the efforts made to investigate the effects of different nano materials on the modifications in the properties of concrete when partial replacement of Cement with fly ash.

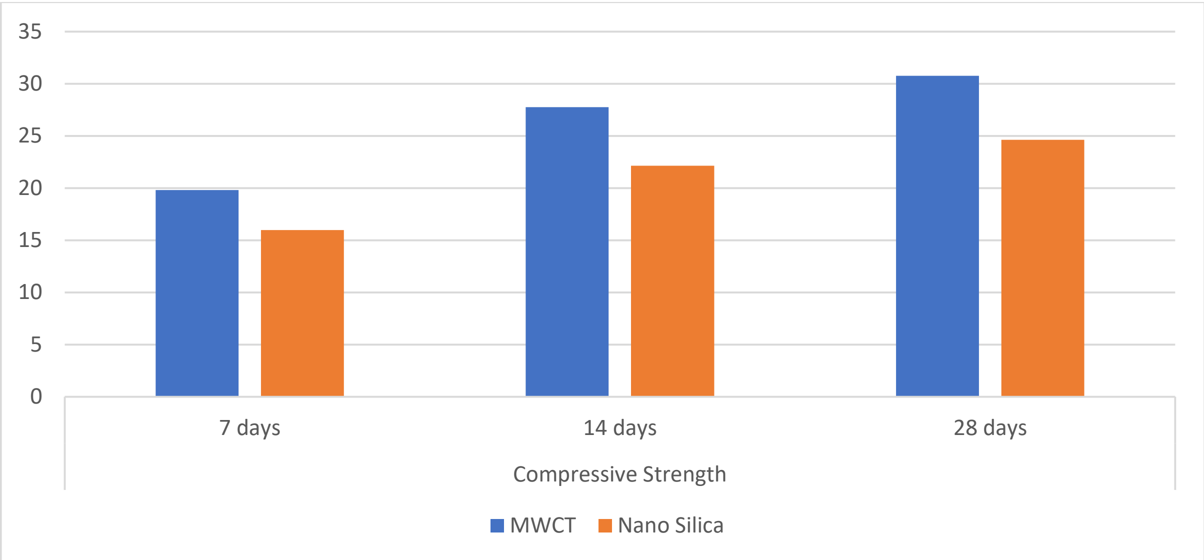
5.2.1. MULTI WALLED CARBON NANOTUBE VS. NANO GRAPHENE OXIDE

The relationship between the compressive strength of Carbon Nanotubes and Nano Graphene Oxide of 45 % replacement of cement with fly ash ,in concrete has been rendered by graphical representation. The number of days is represented by the X-axis and compressive strength in N/mm^2 of concrete at 7 days, 14 days and 28 days is represented by the Y-axis.



5.2.2. MULTI WALLED CARBON NANOTUBE VS. NANO SILICA

The relationship between the compressive strength of Carbon Nanotubes and Nano Silica of 45 % replacement of cement with fly ash, in concrete has been rendered by graphical representation. The number of days is represented by the X-axis and compressive strength in N/mm^2 of concrete at 7 days, 14 days and 28 days is represented by the Y-axis.



VI. CONCLUSION

Nanotechnology has been an emerging topic in the field of concrete, as it helps to improve the mechanical properties of concrete by changing the composites of calcium silicate hydrate at the nano level. In this present investigation, the influence of nanomaterials has been explored on concrete by the evaluation of the compressive strength of concrete at different stages. The concrete was prepared by introducing different nanomaterials at 0.3 percentages with the composite & partial replacement of cement with fly ash mortar and aggregates. The concrete with mix proportioning have water- cement ratio of 0.4 with different percentage of fly ash & cement content were tested at different ages of 7, 14, 28 days. The effect of the different nanomaterials on the mechanical strength of hardened properties of nano concrete can be concluded as follows :

- The concrete with nano materials exhibit superior mechanical properties compared to the ordinary cement concrete.
- The compressive strength of concrete with nanomaterials has a significant increment over the plain cement

concrete.

- The concrete with nanomaterials possesses superior tensile strength properties compared to plain cement concrete.
- Proper visual inspection is recommended during the preparation of nano concrete as the higher content of nano materials has a effect of formation agglomerates during the mixing that disturbs the uniform distribution of nanomaterials throughout the concrete mass.
- The compressive strength of nano concrete significantly improves up to certain content of nanomaterials.
- With the use of 0.3% multi walled carbon nanotubes, the 28 days compressive strength of concrete when partial replacement of cement with fly ash can be increased the compressive strength 15 % compared to the partial replacement of cement with fly ash only.
- On comparing with fly ash, 0.3% multi walled carbon nanotubes with fly ash, gives better compressive strength than fly ash.
- On 28 days compressive strength 0.3% nano graphene oxide,0.3 % multi walled carbon nanotubes & 0.3 % Nano Silica, the compressive strength of multi walled carbon nanotubes is better than other two nano materials.
- This type of concrete is ecofriendly for environmental.

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