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IMPACT OF NANO ADMIXTURE TO IMPROVE THE DURABILITY AND STRENGTH OF CONCRETE

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Abstract: **Nano additives contains various supplementary cementations' materials (SCMs) such as silica, fly ash, clay, and slag are used to improved concrete properties. New Nano modifies (a Nanometer, nm, is 10-9m), with possible applications in concrete technology, have the fine grinded particle size that is less than hundred nm. Nano additives of smaller in size and great potential to expose in large surface area. Nano materials are very reactive, in connection with improving concrete performance such as mechanical strength, durability properties of concrete. The objective of this present investigation is to evaluate the structural strength of Nano modified concrete by Nano silica and Nano clay material as supplementary cementitious material and potential use of nondestructive testing devices for in-situ strength parameters of NMC during and after construction. The concrete specimens of different for different mix proportions were analyzed in the study. This research primarily focuses on the development of experimental evaluation for estimating the 7, 28, 60 and 90 days' compressive strength of concrete. Also 28 days of split tensile strength, flexural strength. To study the behavior of bond action between concrete and steel performed using pullout test at different levels of compressive strength were considered through the use of different Nano modified concretes, and different concentration of Nano modified with conventional curing, acid and saline curing.**

Key Words Nanoparticles; Nano silica; Nano clay; Nanotechnology; Porosity; Durability.

I. INTRODUCTION

Sustainability is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Therefore, sustainable development is disturbed with protecting the world's resources and sharing its benefits for thebetterment of generations to come.

In order to fulfill its commitment to the sustainable development of the whole society, the concrete of tomorrow will not only be more durable, but also should be developed to satisfy socio-economic needs at the lowest environmental impact. Incorporating pozzolnic fly ash (PFA), slag, silica fume (SF) and other industrial pozzolnic by-products in concrete, provides the best economic and technological solution to waste handling, disposal with least impact on environment. PFA, slag, SF and similar materials thus need to be recognized not merely as partial replacements for Portland cement, but as vital and essential constituent of concrete". Thus, using various wastes or by- products in concrete is a major contribution of the 21st century concreteindustry to the sustainable development of human society (Swamy 1998).

roducts from various industries cause a major environmental problem around the world. In order to encourage waste recycling and prevent waste dumping, a landfill tax has also been imposed in the developed countries. However, the waste dumping is still a serious environmental issue throughout the world. Among various by-products generated by the industries, Fly Ash (FA) and Rice Husk Ash (RHA) have attracted much attention by concrete researchers. As stated by Mehta (1998), "the goal of sustainable development of the cement and concrete industries is,therefore, very important, and it can be reached if we make a serious effort for complete utilization of cementitious and pozzolnic by-products produced by thermal power plants and metallurgical industries."

1.2 CEMENT- COMPOSITION AND HYDRATION

Cement can be described as a crystalline compound of calcium silicates (C-S-H) and other calcium compounds having cementitious properties. The four major compounds that constitute cement (Bogue's Compounds) are Tri-calcium silicate, abbreviated as C_3S, Di-calcium silicate (C_2S), Tri-calcium aluminate (C_3A), Tetra-calcium alumino ferrite (C_4AF) where C stands for calcium oxide (CaO), S stands for SiO_2, A stands for Al_2O_3 and F for Fe_2O_3. Tri-calcium silicate and di-calcium silicate are the major contributors to the strength of cement, together constituting about 70 % of cement.

Dry or anhydrous cement does not have adhesive property and hence cannot bind the raw materials together to form concrete. When mixed with water chemical reaction takes place and is referred to as 'hydration of cement'. The products of this exothermic reaction are C-S-H gel and Calcium hydroxide ($Ca(OH)_2$). Calcium hydroxide has lower surface area and hence does not contribute much to the strength of concrete. On hydration of cement aluminates, a product is formed known as high alumina Cement, which has needle like morphology and contributes to some early strength of concrete.

C-S-H gel refers to calcium silicate hydrates, making up about 60 % of the volume of solids in a completely hydrated cement paste. It has a structure of short fibers which vary from crystalline to amorphous form. Owing to its gelatinous structure it can bound various inert materials by virtue of Van der Waal forces. It is the primary strength giving phase in cement concrete.

1.3 **NANO TECHNOLOGY AN INTRODUCTION**

Research on Nanotechnology is a hot topic, as the manufacturing of modern products with dimensions and precision of about

0.1 and 100 nm (1 nm = 1×10^{-9} m). An expert group appointed by the European Commission was not able to agree on a firm definition of Nanotechnology in 1981, but did arrive at a working definition for Nano- science and Nanotechnology (NST) as 'the manipulation, measurement, modeling, precision placement or manufacture of sub-100 Nanometer scale matter' (Glänzel *et al.*, 2003).

The rapid evolution of research in this area is demonstrated by the growth rate of papers published with the 'Nano-' prefix in the title in the period between 1992 and 2001, which increased exponentially with a doubling time of 2 years (Glänzel *et al.*, 2003). Economic estimates regarding advances in Nanotechnology are still more striking: it is predicted that products and services related to Nanotechnology could reach several hundred billion Euros by the end of the decade (NSF, 2001); (Compañó and Hullmann, 2002). Dozens of countries already have national strategies in place and have begun to implement national Nanotechnology plans (Rieke and Bachmann, 2004); (Soltani *et al.*, 2011). According to (Arnall and Parr 2005), countries are trying to establish an advantageous position when Nano technology applications begin to have a significant impact in the world economy and countries are able to exploit these new opportunities to the full'. Europe has assigned 4.865 billion Euros to 'Nano sciences, Nanotechnologies, Materials and New Production Technologies' as part of the 7th Framework Programme for the period of 2007–2013.

1.4 NANOTECHNOLOGY AND CONSTRUCTION

Very few Nanotechnology applications are currently used in the construction sector, which in fact seems to have been somewhat neglected by Nanotech research to date. A search for the terms 'Nanotechnology' and 'eco-efficient construction' in journals listed in Scopus revealed only five research articled and all are related to cement and concrete. Of course, many more researchers examining the role of Nanotechnology in cement and concrete. However, the number is very low compared to other major areas of current research. Moreover, much more work on standardization is required to ensure that high quality investigations into the use Nanotechnology in cement and concrete applications can reach the global market (Sanjuan *et al.*, 2011). It is understandable that Nanotechnology research in today's economically driven society has so far been focused mainly on high profit areas. It is rather strange, however, that the same society so easily forgets the economics of environmental problems such as the probable meltdown of the world economy associated with global warming (Stern, 2006). Nanotechnology priorities should therefore be driven by 'higher' goals; in particular, the 7th UN Millennium Goal related to environmental sustainability should be a major focus of attention. Consequently, the construction industry should also be at the core of the R&Defforts in Nanotechnology, as one of the largest and most active sectors in the world, it will continue to grow at a rapid pace over the coming decades. Most importantly, it has a very high environmental impact, being responsible forthe depletion of large amounts of non-renewable resources and for carbon dioxide gas emissions.

1.5 CONCRETE WITH NANOPARTICLES

Nanoparticles may be obtained either through high milling energy (Sobolev and Ferrada-Gutierrez, 2005) or by chemical synthesis (Lee and Kriven, 2005). They have a high surface area to volume ratio (Fig. 1.2) which provides high chemical reactivity. Most investigations use Nano silica (NanoSiO_2), and Nano-titanium oxide (Nano-TiO_2), while a few use Nano- Fe_2O_3 (Sanchez and Sobolev, 2010). Figure 1.2 shows Specific surface area versus particle size of raw materials used in construction products.

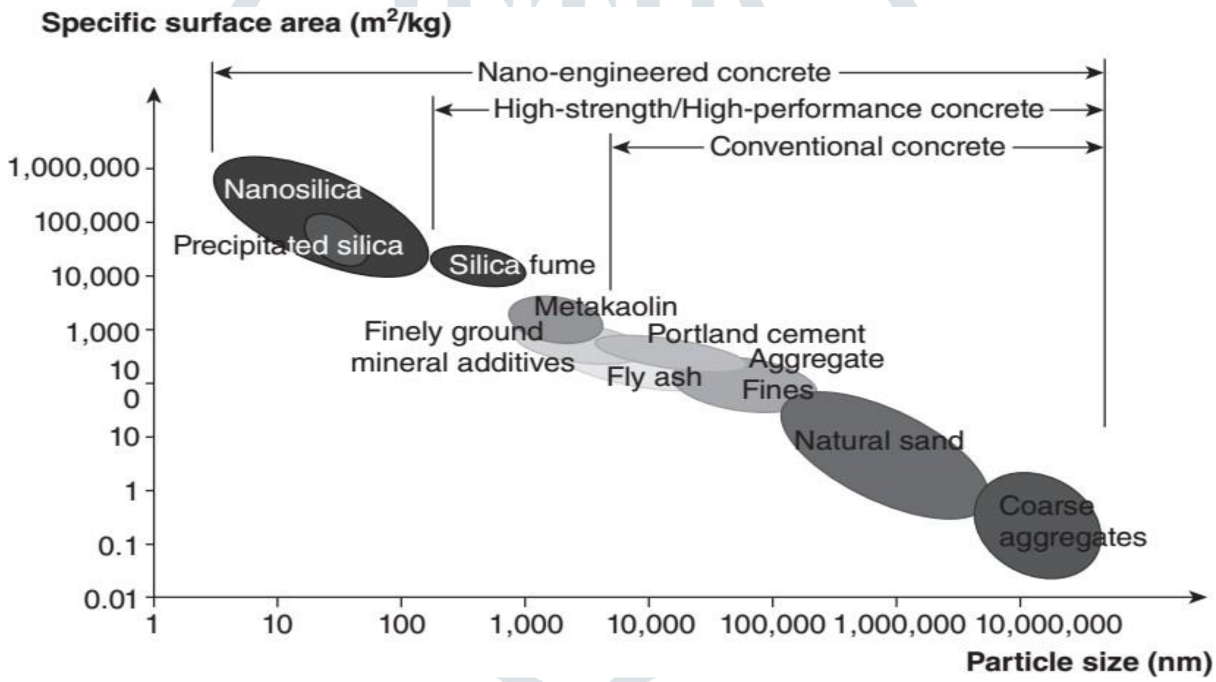

FIGURE1.1: PARTICLE SIZE AND SPECIFIC SURFACE AREA RELATED TO CONCRETEMATERIALS.

1.6 LIFECYCLE OF NANO-ENABLED STRUCTURES

Manufactured Nanomaterials (MNMs) may be released into the environment over the entire lifecycle of the structure, from the time of construction, throughout the use of the structure, and after demolition and disposal. It is important to realize that these materials may transform overtime via physical, chemical, or biological processes. It is important to recognize that much research needs to be conducted to fill in the knowledge gaps regarding aging MNMs in structures. Few studies currently published have investigated long-term physical and chemical changes of imbedded MNMs and the associated hazards. For example, if an MNM is imbedded into a concrete floor or pavement, continual traffic and abrasion will inevitably cause the release of Nanomaterials.

2.0 REVIEW OF LITRATURE

Neville (2006) discussed a wide range of silica products (Fig. 2.1) are manufactured industrially for a different array of applications in all fields. Mainly Silica in all forms is used to reinforcing, thickening and flattening purposes. Wide demand for specialty silica, which include precipitated silica, fumed silica, silica gel and silica sol, will rise 6.3 percent per year to 2.7 million metric tons in 2014

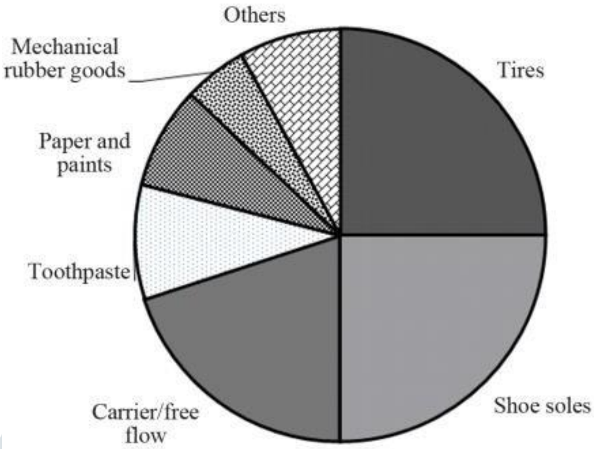

FIGURE 2.1 WORLDWIDE CONSUMPTION AND USE OF SILICA PARTICLES

Sobolev et al. (2009) contribute the research to increasing demands for sustainability, reusing some by-products such as fly-ash, silica fume and Nano-Silica is an attractive option. In fact, several researchers have shown that the utilization of industrial by-products improves variousproperties of concrete and produces eco-friendly materials. Further, the use of Nanotechnology has become widespread in all branches of science. For instance, concrete performance is strongly dependent on Nano-Size dimensions of material such as the Calcium Silicate Hydrates (C-S-H) particles or the gel porosity in the cement matrix. USRNI. (2015) says, using mineral additives such as silica fume orNano-Silica will enhance concrete strength and durability, because of their fine particles, large surface area and high SiO_2 content. However, Nano-Silicais preferred over silica fume because of its smaller particle size and higher surface area. Nano-Silica is silicon dioxide Nano particles (SiO_2), synthetic product of porous and nearly spherical particles, with great potential advantages especially in glass and concrete industries. The size of its particlesare extremely small, approximately 1/100th the size of cement particle. Nano Silica particles, according to their structure, are divided into two types: P-type(Porous particles) and S-type (Spherical particles). P-type Nano-Silica surface contains a number of Nano-porous with the pore rate of 0.611 ml/g; therefore,P-type has much larger surface area comparing to the S-type.

2.1 REVIEW ON DOSAGE OF NANO SILICA

Qing et al. (2007) studied the compressive strength increases with the increase in replacement percentage. Their experiments used an addition of 0, 1, 2, 3 and 5% of Nano-Silica to cement replacement by mass. Their results show great improvement in compressive strength at all ages of testing. Signifying 5% of cement replacement was the optimum.

Montgomery (2010) determined the optimum quantity of materials for mixes depending upon several factors and having subjected to manyperformance constraints are often complex and prolonged. This complexity could be made simple with the utilization of procedures of statistical experimental design and analysis, as the properties of the final product are dependent upon the relative proportions of the components of the mixture rather than their absolute amounts. Moreover, well designed mixture experiments are reasonably effective in identifying the best combination of factors for the achievement of optimized properties of the mixture. Among all the available methods of Design of Experiments (DOE), one method, popularly known as the Factorial design, in which the **q** mixture components are reduced to **q - 1** independent factors by taking the ratio of two-components.

Pane et al. (2012) investigated to adding Nano-Silica with 5% replacing of cement by weight showed higher compressive strength up to 28 days. However, higher percentages of replacing such as 10% didn't have further effect. Also they reported that highest 28-day compressive strength was obtained from 10% Nano Silica +5% silica fumes. The inclusion of silica fume caused substantial reduction in penetration rate of chlorides through reduction of pore connectivity of the mixture.

Sadrmotazi et al. (2010) studied the effect of Poly Propylene fiber along with Nano SiO_2 particles. The Nanosilica was replaced up to 7% which improved the compressive strength of cement mortar by 6.49%. PP fiber amounts beyond 0.3% reduces the compressive strength but beyond 0.3% dose of PP fiber increases the flexural strength, showing the effectiveness of Nano SiO_2 particles. Also up to 0.5% Poly Propylene fiber in mortar water absorption decreases which indicates pore refinement.

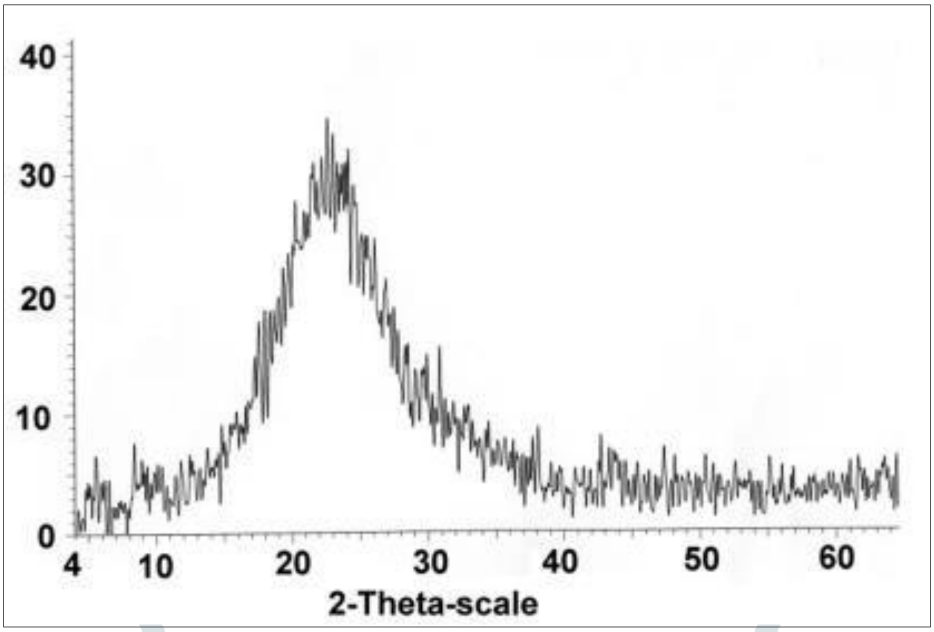

Figure 2.2 X-ray diffraction pattern of Nano-silica

3.0 MATERIAL PROPERTY STUDY

3.1 GENERAL

The main components of this study, Nano Silica and Nano Clay were obtained from Astra Chemicals, Thousand Lights, Chennai. The Acid (Hydrochloric acid, Sulphuric acid) and Saline materials (Ammonium chloride, Magnesium chloride) are obtained from Sujha Surgicals, Nagercoil. Super plasticizer – conplast SP 430 is obtained from Fosroc Chemicals India Private Limited, Ganganagar North, Bangalore.

The cement is obtained from Dalmia cements, India (53 Grade). Fine aggregate (River sand) and coarse aggregate (Blue granite chips) were collected from the nearby locality. The steel (Grade 550) was obtained from Agni steels Private Limited. Potable water is used for the preparation ofspecimen for this research work. The following section describes the properties of materials used.

3.2 CEMENT

Sl.No	Physical properties	Test values	Reference code
1	Specific gravity	3.15	IS:1727-1967
2	Standard consistency	31%	IS:4031-1968 part-4
3	Soundness	0.94mm	Le-chatelier Apparatus IS:4031-1968
4	Initial Setting time	35 minutes	IS:4031-1968 part-5

5	Final Setting time	344 minutes	IS:4031-1968 part-5
6	Compressive strength (28 days)	55.8N/mm^2	-

TABLE 3.1 PHYSICAL PROPERTIES OF CEMENT

Source: Dalmia cement

S.No	Constituent	% of cement
1	Calcium Oxide (CaO)	63.00
2	Silicon di Oxide (SiO_2)	22.00
3	Aluminum Oxide ($A1_2O_3$)	5.00
4	Magnesium Oxide (MgO)	1.32
5	Calcium Sulphate ($CaSO_4$)	4.00
6	Sulphur trioxide (SO_3)	1.84
7	Loss on ignition (LOI)	1.15
8	Chlorides	0.02
9	Lime saturation factor (LSF)	0.87
10	Alkalies	0.80

TABLE 3.2 CHEMICAL PROPERTIES OF CEMENT

Source: Dalmia cement

3.3 FINE AGGREGATES

Fine aggregate collected from Tambiraparani River basin near Tirunelveli has been used for experimental study satisfies the requirement as per IS 383:1970. The aggregate was air dried and screened to remove all foreign matters. The aggregates having fineness modulus 2.62, specific gravity of 2.62 and bulk density of 1.62 g/cm^3. Sand confirming Zone-III and stored in a room and used for casting specimens.

3.4 COARSE AGGREGATES

The coarse aggregates collected from Quarry (Gliend blue metals, of Chunkankadai, Kanyakumari) crushed granite of maximum size 20mm and 12mm conforming to IS 383-1970 was used. The fineness modulus of coarse aggregate 6.75, bulk density of 1.66 g/cm^3 and specific gravity of 2.78.

Gradation			
Fine Aggregate [Figure 4.1]		Coarse Aggregate [Figure 4.2]	
IS Sieve Size	% of Passing	IS Sieve Size	% of Passing
		40 mm	100
10 mm	100	26.5 mm	100

4.75 mm	96.30	20 mm	99.40
2.36 mm	88.30	16 mm	91.20
1.18 mm	71.90	12.5 mm	71.80
600 µm	49.50	10 mm	55.60
300 µm	21.50	4.75 mm	30.50
150 µm	6.90	2.36 mm	12.00
75 µm	0	4.75 mm	6.80

Table 3.3 Gradation and Physical Properties of Aggregate

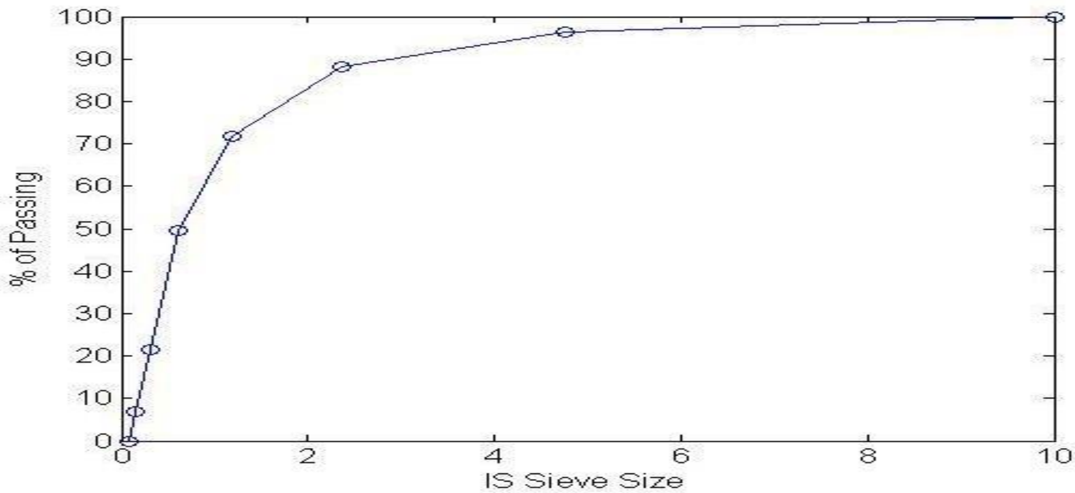

Figure 3.1 Gradation of Fine Aggregate

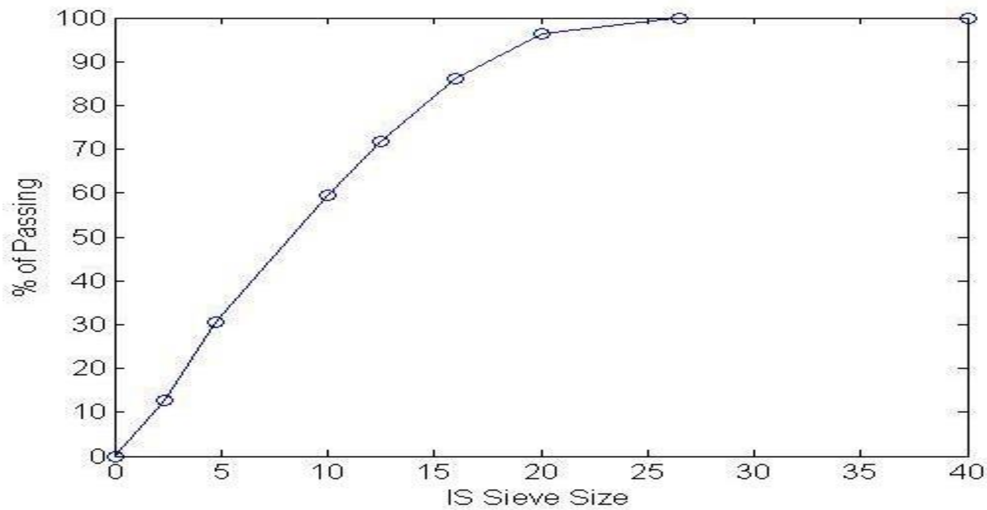

FIGURE 4.2 GRADATION OF COARSE AGGREGATE

3.5 REINFORCEMENT

Yield stress, ultimate tensile stress and percentage of elongation of 10 mm diameter TMT bar were 460 N/mm^2, 598 N/mm^2 and 18% respectively, and 8 mm diameter for TMT bar are 458 N/mm^2, 578 N/mm^2 and 23 %, respectively. All the beams were provided with 0.8 % main tensile reinforcement and 0.55 % compression reinforcement. Figure 3.3 shows the image of reinforcement used for the study.

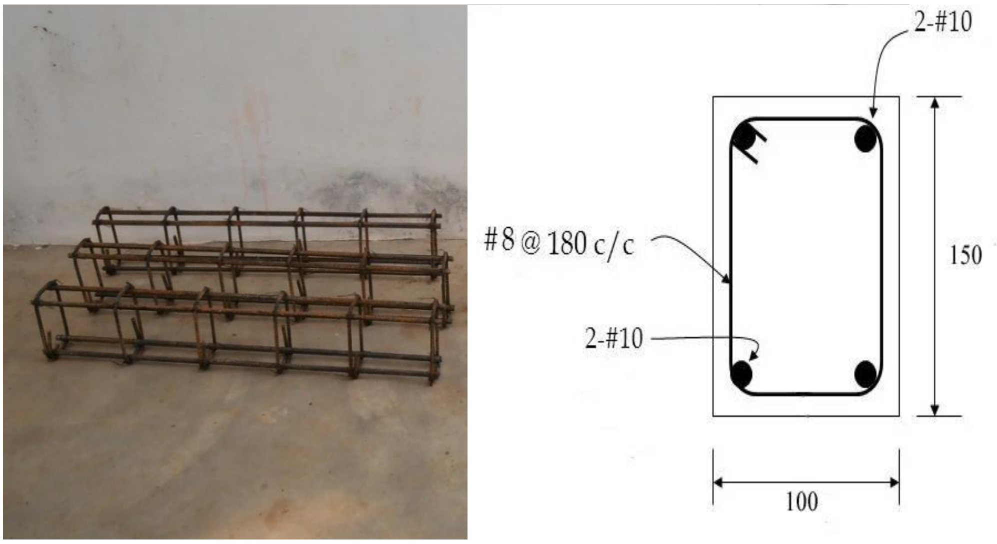

Figure 3.3 Beam Reinforcement

3.6 NANO SILICA

The average size of the Nano silica was found to be 235 nm. From Particle Size Analyzer, the image of which has been in Figure. 4.5. Theproperties of the materials are presented in the Table 3.4.

Contents	**Standard**	**Test result**
Specific Surface area (m^2/g)	200 + 20	202
Specific gravity @ 20^0C	2.00 – 2.40	2.28
pH Value	3.7 – 4.5	4.15
Loss on Drying @ 105 ^0C (5)	< 1.5	0.47
Loss on Ignition @ 1000 ^0C (%)	< 2.0	0.66
Sieve Residue (5)	< 0.04	0.02
Tamped density (g/L)	40 – 60	44
SiO_2 content (%)	> 99.8	99.88
Carbon content (%)	< 0.15	0.06
Chloride content (%)	< 0.0202	0.009
Al_2O_3	< 0.03	0.005
TiO_2	< 0.02	0.004
Fe_2O_3	< 0.003	0.001

TABLE 3.4 PROPERTIES OF NANO SILICA

FIGURE 3.4 IMAGE OF NANO SILICA

3.7 NANO CLAY

The Nano clay used in this experiment was Metakaolin (Cloisite- 15A and Nanofill-15). High-purity kaolinitic clays can be calcined at relatively low temperature (600-700º C) to keep silica and alumina in amorphous state. Then pulverized the top particles smaller than 2 microns.The product is a highly reactive pozzolana of white color that is especially suitable for use in architectural concrete. Figure. 3.5 shows the image of NanoClay used for the study and the properties of Nano clay was listed in Table 3.5.

FIGURE 3.5 IMAGE OF NANO CLAY

Contents	Formula	Test result	Standard
Silica	SiO_2	45.00	47.00
Alumina	Al_2O_3	36.00	37.00
Ferric Oxide	Fe_2O_3	00.70	01.00
Calcium Oxide	CaO	00.15	00.50
Magnesium Oxide	MgO	00.17	00.50

Titanium Dioxide	TiO_2	00.15	00.50
Loss on Ignition	L.O.1 L	14.00	15.00
Potassium	K_2O	00.10	00.50
Sodium	Na_2O	00.10	00.50
Specific gravity @ 20^0C	-	2.6	2.3 – 3.0
Brightness	-	78.00	-
Whiteness	-	80.00	-
Acid Solubility	-	01.20	02.00
Water Absorption	-	36 ml/100gm	38 ml/100gm
Oil absorption	-	32 ml/100gm	34 ml/100gm
Moisture	-	02.00	03.00
pH Value @ 10% Sol	-	07.00	08.00
Bulk Density	-	0.50 g/cc	0.66 g/cc
Relention on 500 mosh	-	0.30	0.50

Table 3.5 Properties of Nano clay

3.8 AMMONIUM CHLORIDE

Ammonium Chloride - [NH_4Cl = 53.49] is a white crystalline solid. It is soluble in water (37%). The primary hazard of Ammonium Chloride is it is dangerous if exposed to the environment. The Ammonium Chloride used for the study was shown in Figure 4.7 and the properties are listed in Table 3.6.

Figure 3.6 Image of Ammonium Chloride

Contents	Standard
Asssay	- 99% min
Sulphate (SO_4)	- 0.03% max
Calcium (Ca)	-nil-
Lead (Pb)	- 0.001% max
Iron (Fe)	- 0.002% max
Phosphate (PO_4)	- 0.002% max
10% Aquerus Solution	- Clear and Colour less
Nonvolatile matter	- Nil

Table 3.6 Properties of Ammonium Chloride

3.9 MAGNESIUM CHLORIDE

Magnesium Chloride - [$MgCl_2.6H_2O$ = 203.31] salts are typical ionic halides, being highly soluble in water. The hydrated magnesium chloride can be extracted from brine or sea water. The Magnesium chloride used for the study has shown in Figure 4.8 and the properties are outlined in Table 3.7.

Figure 3.7 Image of Magnesium Chloride

Contents	Standard
Asssay	- 97% min
Sulphate (SO_4)	- 0.04% max
Calcium (Ca)	- 0.01% max
Lead (Pb)	- 0.001% max
Iron (Fe)	- 0.002% max
Phosphate (PO_4)	- 0.004% max

10% Aquerus Solution	- Clear and Colour less
Nonvolatile matter	- 0.1% max

Table 3.7 Properties of Magnesium chloride

3.10 CONCRETE MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportion with objectof producing concrete of certain minimum strength and durability as economical and possible. The purpose of design was divided into two stages. First object was to achieve the stipulated minimum strength and durability. The second object was to make the concrete in most economical manner.

W/C Ratio	CEMENT (Kg)	F.A (Kg)	C.A (Kg)
141 lit	403	665	1177
0.35	1	1.65	2.92

TABLE 3.8 PROPORTION OF MIX-RATIO

Mix Proportion	Without Nano silica and 0%, 2 %, 4 %, 6% of Nano Clay			
Nano Silica	0 % by weight of Cement			
Nano clay	0	2	4	6
Mix identity	M_{00}	M_{02}	M_{04}	M_{06}
Mix Proportion	2 % Nano silica and 0%, 2 %, 4 %, 6% of Nano Clay			
Nano Silica	2 % by weight of Cement			
Nano clay	0	2	4	6
Mix identity	M_{20}	M_{22}	M_{24}	M_{26}
Mix Proportion	4 % Nano silica and 0%, 2 %, 4 %, 6% of Nano Clay			
Nano Silica	4 % by weight of Cement			
Nano clay	0	2	4	6
Mix identity	M_{40}	M_{42}	M_{44}	M_{46}
Mix Proportion	6 % Nano silica and 0%, 2 %, 4 %, 6% of Nano Clay			

Nano Silica	6 % by weight of Cement			
Nano clay	0	2	4	6
Mix identity	M_{60}	M_{62}	M_{64}	M_{66}

(The Mix M_{24} indicates 2% Nano silica and 4% Nano clay in modified Nanoconcrete)

TABLE 3.9 MIX PROPORTIONING WITH VARIOUS REPLACEMENT OF NANOAGGREGATE

Mix ID	Cement	Nano Silica	Fine Aggregate	Nano Clay	Coarse Aggregate	W/C Ratio	Super Plasticizer
M_{00}	1	0	1.658	0	2.92	0.350	0.06
M_{02}			1.624	0.02			0.06
M_{04}			1.591	0.04			0.06
M_{06}			1.559	0.06			0.08
M_{20}	0.98	0.02	1.658	0	2.92	0.350	0.06
M_{22}			1.624	0.02			0.06
M_{24}			1.591	0.04			0.08
M_{26}			1.559	0.06			0.08
M_{40}	0.96	0.04	1.658	0	2.92	0.350	0.06
M_{42}			1.624	0.02			0.08
M_{44}			1.591	0.04			0.08
M_{46}			1.559	0.06			0.10
M_{60}	0.94	0.06	1.658	0	2.92	0.350	0.08
M_{62}			1.624	0.02			0.08
M_{64}			1.591	0.04			0.10
M_{66}			1.559	0.06			0.10

TABLE 3.10 MIX PROPORTION OF CONCRETE WITH CONVENTIONAL AGGREGATE ANDVARIOUS NANO SUBSTANCES [NANO SILICA AND NANO CLAY]

Mix ID	Cement kg/m³	Nano Silica kg/m³	Fine Aggregate kg/m³	Nano Clay kg/m³	Coarse Aggregate kg/m³	Water l/m³	Super Plasticizer l/m³
M_{00}	403	0	665.67	0	1177	141.05	8.70
M_{02}			652.35	13.31			8.70
M_{04}			639.05	26.62			8.70
M_{06}			625.73	39.94			11.60
M_{20}	394.94	8.06	665.67	0	1177	138.29	8.70
M_{22}			652.35	13.31			8.70
M_{24}			639.05	26.62			11.60
M_{26}			625.73	39.94			11.60
M_{40}	386.88	16.12	665.67	0	1177	135.40	8.70
M_{42}			652.35	13.31			11.60
M_{44}			639.05	26.62			11.60
M_{46}			625.73	39.94			14.50
M_{60}	378.82	24.18	665.67	0	1177	132.58	11.60
M_{62}			652.35	13.31			11.60
M_{64}			639.05	26.62			14.50
M_{66}			625.73	39.94			14.50

TABLE 3.11 MIX PROPORTION OF CONCRETE BY WEIGHT BATCHING

4.0 EXPERIMENTAL WORK AND RESULT ANALYSIS

4.1 General

Fresh concrete is a freshly mixed material which can be moulded to any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in wet state as well as hardened state. For a concrete technologist, a comprehensive knowledge of workability is required to design a mix. workability is a parameter, a mix designer is required to specify in the mix design process, with full understanding of the type of work, distance of transport, loss of slump, method of placing, and many other parameters involved. Assumption of right workability with better understanding and the ability to work in concrete can be handled without segregation and without loss of homogeneity. Strength properties are one of the important parameters of concrete. Strength of concrete is its resistance rupture. It may be measured in a number of ways, such as, strength in compression, in tension, in shear or in flexure. All these indicate strength withreference to a particular method of testing.

Mix ID	Water Cement Ratio (W/C)	Super Plasticizer	Slump in mm
M_{00}	0.35	0	60

Table 4.1 Slump Value of Conventional Concrete

Mix ID	Super Plasticizer	Slump mm	Mix ID	Super Plasticizer	Slump mm
M_{00}	0.2	90	M_{20}	0.2	90
	0.4	120		0.4	110
	0.6	-		0.6	-

	0.8	-		0.8	-
	1	-		1	-
M_{02}	0.2	85	M_{22}	0.2	85
	0.4	110		0.4	100
	0.6	-		0.6	105
	0.8	-		0.8	-
	1	-		1	-
M_{04}	0.2	70	M_{24}	0.2	55
	0.4	100		0.4	70
	0.6	125		0.6	85
	0.8	-		0.8	110
	1	-		1	-
M_{06}	0.2	60	M_{26}	0.2	50
	0.4	90		0.4	65
	0.6	115		0.6	80
	0.8	-		0.8	100
	1	-		1	-
M_{40}	0.2	60	M_{60}	0.2	85
	0.4	80		0.4	90
	0.6	110		0.6	100
	0.8	-		0.8	120
	1	-		1	-

TABLE 4.2: SLUMP VALUES WITH SUPER PLASTICIZER FOR NANO MODIFIED CONCRETE

Mix ID	Super Plasticizer	Compaction Factor	Workability	Mix ID	Super Plasticizer	Compaction Factor	Workability
M_{00}	0.2	0.88	Low	M_{20}	0.2	0.89	Low
	0.4	0.93	Medium		0.4	0.93	Medium
	0.6	-	-		0.6	-	-
	0.8	-	-		0.8	-	-
	1	-	-		1	-	-
M_{02}	0.2	0.93	Medium	M_{22}	0.2	0.88	Low
	0.4	0.95	High		0.4	0.90	Medium
	0.6	-	-		0.6	0.93	Medium

	0.8	-	-		0.8	-	-
	1	-	-		1	-	-
M_{04}	0.2	0.83	Low	M_{24}	0.2	0.82	Low
	0.4	0.92	Medium		0.4	0.87	Low
	0.6	0.96	High		0.6	0.91	Low
	0.8	-	-		0.8	0.93	Medium
	1	-	-		1	-	-
M_{06}	0.2	0.84	Low	M_{26}	0.2	0.79	V.Low
	0.4	0.88	Low		0.4	0.82	Low
	0.6	0.92	Medium		0.6	0.90	Low
	0.8	-	-		0.8	0.95	High
	1	-	-		1	-	-

Table 4.3 Compaction Factor test results for Nano modified concrete

Mix ID	**Super Plasticizer**	**% of flow**	**Consistency**	**Mix ID**	**Super Plasticizer**	**% of flow**	**Consistency**
M_{00}	0.2	60	Stiff	M_{20}	0.2	56	Stiff
	0.4	100	Plastic		0.4	96	Plastic
	0.6	-	-		0.6	-	-
	0.8	-	-		0.8	-	-
	1	-	-		1	-	-
M_{02}	0.2	95	Plastic	M_{22}	0.2	55	Stiff
	0.4	110	Wet		0.4	75	Plastic
	0.6	-	-		0.6	86	Plastic
	0.8	-	-		0.8	-	-
	1	-	-		1	-	-
M_{04}	0.2	52	Stiff	M_{24}	0.2	35	Stiff
	0.4	89	Plastic		0.4	48	Stiff
	0.6	100	Wet		0.6	60	Stiff
	0.8	-	-		0.8	74	Plastic

	1	-	-		1	-	-
M_{06}	0.2	40	Stiff	M_{26}	0.2	20	Dry
	0.4	55	Stiff		0.4	45	Stiff
	0.6	64	Plastic		0.6	72	plastic
	0.8	-	-		0.8	106	Wet
	1	-	-		1	-	-

Table 4.4 Flow Table Test Results for Nano Modified Concrete

Workability description	Slump in mm	Compaction factor	Vee Bee time Sec
Extremely dry	-	-	32 – 18
Very stiff	-	0.70	18 – 10
Stiff	0 – 25	0.75	10 – 5
Stiff plastic	25 – 50	0.85	5 – 3
Plastic	75 – 100	0.90	3 – 0
Flowing	150 – 175	0.95	0

TABLE 4.5 ILLUSTRATE THE VEE-BEE STANDARD FROM IS1199-1959

Mix ID	Super Plasticizer	Time in Sec	Workability	Mix ID	Super Plasticizer	Time in Sec	Workability
M_{00}	0.2	8	Stiff	M_{20}	0.2	7	Stiff
	0.4	3	Plastic		0.4	2	Plastic
	0.6	-	-		0.6	-	-
	0.8	-	-		0.8	-	-
	1	-	-		1	-	-
M_{02}	0.2	3	Plastic	M_{22}	0.2	6	Stiff
	0.4	0	Wet		0.4	3	Plastic
	0.6	-	-		0.6	2	Plastic
	0.8	-	-		0.8	-	-
	1	-	-		1	-	-

M_{04}	0.2	6	Stiff	M_{24}	0.2	10	Stiff
	0.4	3	Plastic		0.4	8	Stiff
	0.6	0	Wet		0.6	5	Stiff
	0.8	-	-		0.8	3	Plastic
	1	-	-		1	-	-
M_{06}	0.2	9	Stiff	M_{26}	0.2	15	Dry
	0.4	6	Stiff		0.4	8	Stiff
	0.6	3	Plastic		0.6	3	plastic
	0.8	-	-		0.8	0	Wet
	1	-	-		1	-	-

Table 4.6 Vee-Bee consistency test results for concrete

4.2 MICROSCOPIC ANALYSIS

To study the microstructure properties of the samples using SEM. The broken piece of each Nano Modified specimens are used for the test. The formation and deformation of phases and changes inside the Micro Structure was identified this test.

4.3 SCANNING ELECTRON MICROSCOPIC (SEM)

SEM is mostly used to observe morphology, structural and surface properties of the polymer surfaces. SEM uses secondary electrons generated from either thermal or field emitting cathode. Condenser and an objective electromagnetic lens attenuate the generated electron beam.Electron beam was scanned by electromagnetic coils placed in the back-focal plane of the objective lens and in most cases the secondary electron signal was collected by electron detector. Figure 5.5 (a), (b), (c), (d), Figure 5.6 (a), (b), (c), (d), and Figure 5.7 (a), (b), (c), (d), shows the SEM photographs for various samples.

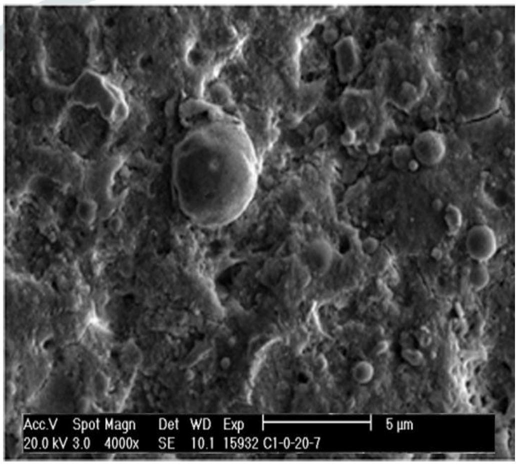

Figure 5.5-(b) Concrete filled withNano Clay of M_{02}

FIGURE 4.1-(A) SEM IMAGE OF NANOCLAY

4.2 X-Ray Diffraction Study (XRD)

XRD is one of the most widely used technique for investigating both quantitative and qualitative phase analysis and provides information regarding specific components. The purity of the substance was obtained from the powder diffraction analysis relating to the structure of allotropic transformation. Transition to different phases and the purity of the substances are obtained. The diffracted intensities were recorded with powder diffract meter.

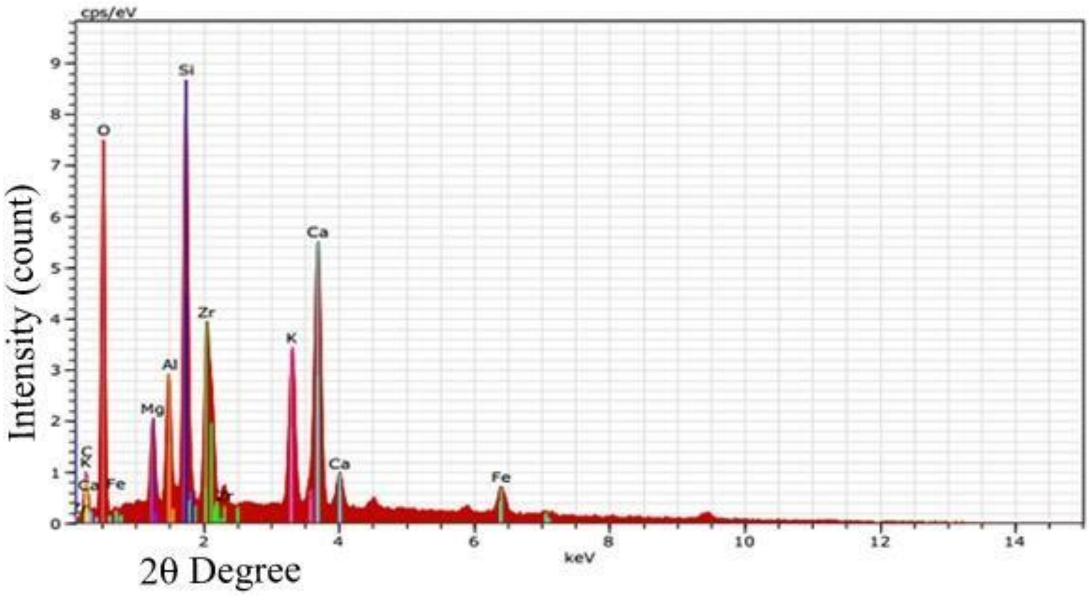

Figure 4.1-(a) Chemical Composition of Conventional Concrete Mix (M_{00})

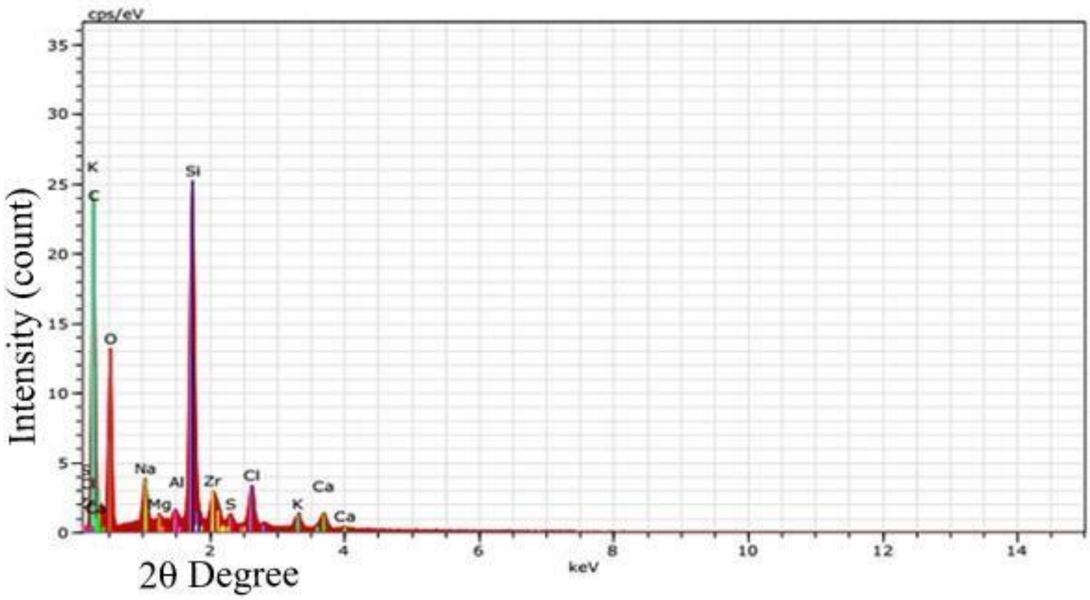

Figure 4.1-(b) Chemical Composition of Modified Concrete Mix (M_{22})

5.0 CONCLUSIONS

1. In the XRD analysis of the Nano silica and Nano clay nano composites, the disappearance of the peak in the M_{24} (2% of Nano silica with 4% of Nano clay) nanocomposites designates the separation of silica and clay layers and the formation of interpolated structures. The optimum replacement of Nano composites are confirmed in the

transmission electron microscopicstudies.

2. The TEM and SEM images of 2 % Nano silica with 4 % of Nano clay loadings show evidence of introduced moderate structures of optimum Nano composites. These structures were responsible for the increase in properties at different replacement rates of Nano composites.

3. From the experimental results, Nano additives in concrete increases the density of about 10 to 20 percentage thereby the self–weight of the concrete was accomplished. Nano additive concrete was having the slump value lies between 75 and 110 mm.

4. The compressive strength of nanocomposites shows the addition of Nano modified concrete improves the compressive strength of 85 N/mm^2; it was obtained for mix M_{24}, which is 25 to 35% greater than the controlled Mix M_{00}, an increase in material stiffness with an increase in nano clay ranges up to 4 %. This was suggestive of the stiffness increasing with increasing Nano additives.

5. Flexural strength was precise and that the addition of Nano modified concrete improves the flexural strength of 5.80N/mm^2 at 28 days of curing; it was obtained from the mix M_{24}, which is 40%greater than the controlled Mix M_{00}.

6. The effective strength of Reinforced concrete beam was 103.50 N/mm^2; it was obtained for mix M_{24}, which was 54% more with controlled Mix M_{00}. The load carrying capacity of Nano modified was increases by 80 %, at a threshold of 2% Nano silica with 4 % nano clay loadings.

7. Due to the pore filling effect Nano additives cover large surface area, and it may arrest all the pours inside the concrete, so that the durability of Nano admixture based concrete may also be improved.

8. The SEM study on the fractured surfaces of the various Nano modified concrete has identified the morphological changes of the internal structures. This indicates, there is a good interfacial adhesion between the nano silica & nano clays to the cementwhich may be responsible for the improvement in tensile strength.

9. The permeability values for Nano modified concrete in water was observed, Nano modified Mix of M_{00}, M_{02}, M_{22} and M_{24} are to be 9.8 x $10^{-12}m^2/s$, 7.2 x $10^{-12}m^2/s$, 3.90 x 10^{-12} m^2/s and 5.58 x 10^{-12} m^2/s were obtained. It is to be evidence that the Nano modifies gives better impermeable medium, so that its gives better results indurability and resistance against corrosion.

10. Cement manufacturing process produces released equal quantityof carbon di oxide, cement is only considered as the most environmentally harmful ingredient in concrete. The admixtures Nano-silica and Nano clay have the potential to replace cement in the mixture, which would drive down the cost of concrete as well as reduce its carbon footprint.

11. Nano additives gives significant effect of local exposure conditions, the addition of Nano clay and Nano silica could produce the concrete with improved performance, life costs, and also a lessened adverse effect on the environment.

12. An initial crack load of 30 kN was attained at design mix M_{00} concrete reinforced with 10mm diameter bars and an initial crack load of 45 kN the Mix M_{24} concrete reinforced with 10mm diameter bars resulted with. This showed that in Nano modified concrete the change in Nano admixture ratio influenced the initial crack load.

5.1 SCOPE FOR FUTURE RESEARCH

Although a lot of works has been carried out with the use of Nano materials in concrete, a proper understanding has not been developed. Infuture, the size effects of nano particles such as Nano silica, Nano clay can be studied in detail. A detailed study of the microstructure at specific intervals throughout a year can give a very good idea about the reactions taking placein the concrete. Looking at the price of the Nano additives new methods can be designed for its production at a low cost.

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