ISSN No:-2456-2165

An Experimental Study on Mechanical Properties of Concrete using Nano Silica

Dhanush Kalal
Civil Engineering Department Pacific University,
Udaipur, Rajasthan

Aiwant Chandaliya
Assistant Professor,
Civil Engineering DepartmentPacific University,
Udaipur, Rajasthan

Abstract:- The Durability of Concrete has been vital to all the manufacturer and researchers. The Concrete has been on top always in providing Strength and durability of structures. On other side, we have been facing many challenges like long term Poor Performance, less durable, poor performance against acid and sulphate attack etc. Many researchers are working to improve these drawbacks using nano particles. Nano technology is one of the emerging techniques to improve the mechanical properties of concrete as well as the performance of concrete. The modifications are required to sort out these problems in concrete mass. It has been seen that using nano particles material, the tensile strength, susceptibility to chemical attack, corrosion of reinforcement, low durability has been sorted out up to a good extent. In this study, I have tried to improve mechanical and chemical properties of concrete like Compressive strength, durability, resistive against corrosion, acid attack resistance, workability etc. using Nano Silica material. The target study is to get the best proportion of concrete ingredient added with nano silica and to get the best out come with that proportion in terms of better mechanical and Chemical Properties.

Keywords:- *Durability; Compressive Strength; Nano Silica, Split Tensile Strength; Nondestructive tests.*

I. INTRODUCTION

Concrete is the most consumable construction material on the earth after water. It is necessary to develop the concrete in a such a way that it can fulfill the requirement of present construction industry in terms of strength and durability. There is necessity to design the same as eco-friendly or environment friendly material. The Core ingredient of Concrete are Cement, Sand, Aggregate and water. The Strength of concrete depends upon physical and chemical properties of these materials directly. The Portland Cement was invented by Mr. Joseph Aspin in year 1824. Since then, the research and development work has been going to make it more user and environmentally friendly.

Earlier in 60's, the concrete was developed which could give strength of M-25 to M-40, considered as High Strength Concrete. Then after many years of research and development progress, researchers have developed Ultra High-Performance Concrete which can give not only greater Strength but also performance in service life of structure. Scientist have found the material which having very small particle size between 1 Nano meter to 100 Nano meters. They have started using this material into the concrete mix as a replacement of existing cementitious material cement. They called it as Nano materials. Over a period, the positive results could be seen by incorporating these materials. Researchers have shown the positive results and started going into deep about this research. The Nano Particles can be used as a cementitious material because their particles fill the gap between ingredient of concrete. They have been working on it for getting the best proportion of ingredient which give maximum strength. The Compressive Strength, Durability and workability can be enhanced by adding nano materials.

The analysis of all ingredient of concrete is important before using it into the mix. The characterization of material of concrete mix plays vital role in physical and chemical property of concrete. The performance of concrete must be assessed in a proper way so that clear conclusion can be given. The performance of such type of concrete must be assessed by molecular level modeling.

The Nano particles having unique physical, Chemical and Optical Properties. These covers more surface area as compared other ingredients or other conventional concrete. The Development of nano particles needs multi-dimensional approach, Design experts and Material scientist in research for getting best outcome of efforts.

In this emerging technology, the approach is to get the concrete material which having integration of self sensing and self-powered material. This technology can help us to improve compressive strength, Tensile Strength, Workability, and durability can be enhanced.

Moreover, Nano particles are able to enhance the durability and shrinkage with reducing permeability of concrete.

To improve the durability and stability of concrete for service life of structure, nano silica and aluminum oxide can be used. These can improve structural stability in terms of resistance against sulphate attack, abrasion of material, corrosion of material etc. Hence, Nano technology plays a important role in the development of concrete with high strength. Adding nano silica can provide low strength of concrete. Nano technology plays vital role in the development of high strength and high performance of concrete as well.

ISSN No:-2456-2165

For many applications in pavement design, these can be used.

II. MATERIALS

A. Materials

➢ *Nano Silica:*

In this study Nano Silica (SiO_2) have been used to In this study, I have used nano silica (SiO_2) as a Nano material for adding into the concrete mix to get rich properties of concrete and the intermolecular bonding between the ingredients of concrete will be boosted up to great extent. The mechanical Property of Nano Silica emphasizes to increase the Mechanical property of concrete.

- Physical Composition of Nano Silica (SiO_2):

Color: White
Specific Gravity: 2.63
Bulk Density: 2580 kg/m^3
Fineness: > 340 m^2/kg
Mass of SiO_2 (Molar Mass): 59.2301 g/mol
Size of particles: Less than 20 Micron

➢ *Cement:*

The cement is the core cementitious material used in the concrete mix. The property of the cement makes direct impact on the mechanical property of the concrete and durability as well as performance of concrete. Before using cement into the concrete things must be clear about the quality and grade of the cement. If the cement quality and grade is low then it will create direct impact on the compressive strength of the concrete. The following are the physical property of the cement which has used in the present study:

Grade of Cement: 53 (OPC)
Maximum Fineness: 3800 gm/cm^2.
Minimum 7 days Mortar cube strength: 28.17 N/mm2
Mortar Air Content: 8-12 %

➢ *Fine and Coarse Aggregate:*

The fine and coarse aggregate are the core ingredient of the concrete mix. The major volume of the concrete covered it by coarse aggregate. Before adding fine aggregate and coarse aggregate into the concrete, the property of these ingredients must be very clear. The fine and coarse aggregate will have direct impact on compressive strength and performance of the concrete. The mixing way and method of using fine and coarse aggregate will also have a significant impact on strength of the concrete. The fineness modulus of the fine aggregate must be in the range between 2.3 to 3.2. When the concrete is poor in bonding and framing of the ingredient then vibration methods are used to eliminate the voids and air between the ingredients of concrete to get early settlement and early strength of the concrete. The proper dispersion of material is very essential for making homogeneity results into which the strength and performance of the concrete improves. The fine and course aggregates are available in the ample amount in the nature. Force aggregates are made by physical disintegration of the rocks, crushed gravel and stones. The property of the aggregate depends on the parent row therefore it is mandatory to perform the queue test before using it into the concrete mix.

➢ *Admixture:*

To achieve higher strength and performance it is essential to use admixtures into the concrete mix. If we talk about the admixture usually used, we would have water reducer admixture and high strength admixtures are commonly used. Add mixtures are capable to increase the inherent quality of the concrete and improving the strength of the concrete as well. The cohesion bond between the concrete will be enhance using admixtures pertaining these certain qualities. As per the recommendation of doses the quantity of chemical admixture should be in the range of 0.32 to 1.4% by weight of the cement. It is also recommended that the dose of admixture should not be greater than a maximum limit otherwise it would have the negative impact on the concrete mix. Sometimes the negative impact can be seen early time and sometimes it can be seen after a long run.

III. METHODS AND EXPERIMENTAL DATA

A. Concrete Mix Design:

In the present, study we have done the concrete mix design process using IS10262. Apart from the regular ingredient of the concrete the nanoparticles have incorporated into the concrete mix. Different water cement ratios have used to identify the best proportion of the ingredients on which we get the maximum strength. The water cement ratio was taken as 0.25,0.3 and 0 .4 respectively. For every water cement ratio, we made 9 different mix trial and we have performed the various test including compressive strength after 7 days, 14 days, 21 days and ultimate strength observed on 28 days. This process was done to get the physical property and chemical property of the concrete when all the tests are done on trial mixes.

The Nano Silica have been used as a nano material. We have added Nano Silica at the rate of 8% and 12% as a replacement of cement quantity. For both proportion individual cubes were casted and the compressive strength as well as other test were done on those mixes.

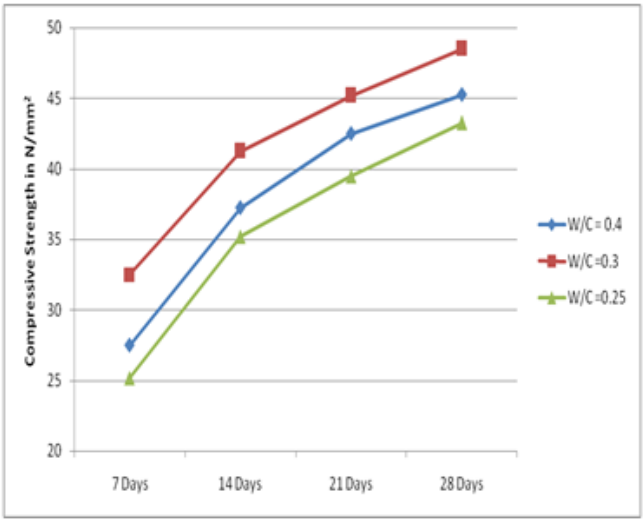
➢ *Compressive Strength Test:*

The Following observation were taken on compressive testing machine as compressive strength value.

ISSN No:-2456-2165

Table 1: Compressive Strength Observations on M-50

Mix	NS (%)	W/C	Compressive Strength (N/mm2)			
			7th Day	14th Day	21st Day	28th Day
M-50	0	0.4	25.2	36.5	42.2	51.8
		0.3	31.5	41.2	43.5	52.2
		0.25	26	34.2	38.7	51.4
M-50	8	0.4	28.5	38.2	43.5	46.2
		0.3	33.5	42.2	46.2	53.2
		0.25	26.2	36.2	40.5	44.2
M-50	10	0.4	26.3	36.2	41.2	43.2
		0.3	31.4	37.5	41.5	44.5
		0.25	26.5	35.6	41.5	43.5



Graph-1 Comparative Graph for Compressive Strength results

➢ *Split Tensile Strength Test:*

The split tensile strength test of the concrete used to identify the tensile strength of the concrete across the vertical diameter of the sample. This method is also known as indirect method to identify the split tensile strength of the concrete. The specimen is prepared with the same concrete proportion on which compressive strength results was better. By using those proportions, the sample have prepared and tested.

Table 2: Split Tensile Strength Comparison

Mix Design	Nano Silica (%)	Split Tensile Strength Value (N/mm2)		
		7 Days	14 Days	28 Days
M-50 Conventional Concrete	0	5.3	6.9	8.2
M-50	8	6..1	7.1	8.9
M-50	10	5.6	6.4	7.2

➢ *Flexural Strength Test:*

This test is used to identify the flexural strength of the concrete specimen. The proportion is so selected as per the compressive strength result on which the best outcome was found in the compressive strength result. The flexural tensile strength is differed from the normal tensile strength. For conducting this test, a specimen is prepared with having dimension 150 mm x 150 mm and the length is considered as 700 mm. This method is mainly based on the bending of the concrete specimen against the load applied on it.

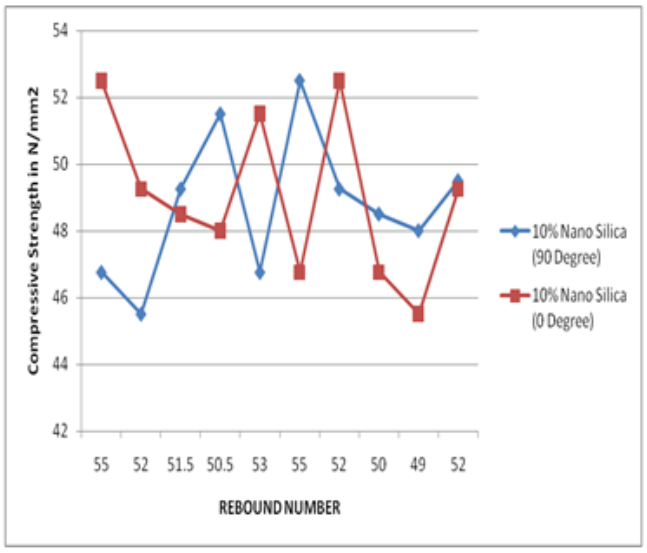
Table 3: Flexural Strength Test Comparison

Mix Details	Replacement of Cement by NS (%)	Flexural Tensile Strength (N/mm2)		
		7 Days	14 Days	28 Days
M-50 Conventional Concrete	0	7.1	9.0	10.7
M-50	8	7.5	9.25	11.5
M-50	10	7.0	8.3	9.7

➢ *Non-destructive Test:*

Non-destructive test are the tests in which physical disintegration of the material is not required. Using these tests without any physical disintegration, we can calculate the compressive strength and other properties of the concrete specimen. Rebound hammer method is very convenient method by which we can calculate the compressive strength value on different spots on the surface of the concrete without any physical dismantling. surface.

ISSN No:-2456-2165



Graph-2 Comparative Graph for Rebound Hammer Test Values

IV. CONCLUSIONS

The following conclusions have been made in the study as per the result found:

- The Nanomaterial Nano silica having capacity to enhance the mechanical properties of the concrete as well as durability.
- The compressive strength observation was found maximum on 8% incorporating of nano silica is 53.2 MPa.
- It is also found that adding 8% nanosilica as a replacement of cement provides better resistance to sulfate attack as compared to conventional concrete.
- The observation of split tensile strength was found maximum 8.8 megapascal on adding 8% nano silica as a replacement of cement. Further, when we increase the amount of Nano Silica, the split tensile strength and compressive strength decreases.
- The observation of flexural strength test was found maximum 11.5 MPa at the incorporation of Nano Silica by 8%. Further when we add or increase the amount of nano silica the result gets decreases.
- We have done cost effective analysis to reduce the overall costing. We found that the replacement of Nano Silica reduces 10 to 12% in cost cutting as compared to conventional concrete.
- The non-destructive test results also indicated that the uniformity and homogeneity of ingredients of concrete was in good condition.
- The use of a nano-silica improves the workability property of concrete mix.

REFERENCES

[1]. Salomaa, Amrinsyah Nasutionb , Iswandi Imranb , Mikrajuddin Abdullahb, “Improvement of concrete durability by nanomaterials”, ScienceDirect Journal 2015.
[2]. Arti S. Pharande1, Dr. Geetha K. Jayaraj, Sanjeev Raje, “Nano Technology in Concrete- A Brief Review”, International Research Journal of Engineering and Technology, 2019.
[3]. Chenglong Zhuang and Yu Chen, “The effect of nano-SiO2 on concrete properties: a review”, De Gruyter publications, 2019.
[4]. Sen Du, Junliang Wu, Othman AlShareedah, and Xianming Shi, “Nanotechnology in Cement-Based Materials: A Review of Durability, Modeling, and Advanced Characterization”, Multidisciplinary Digital Publishing Institute (MDPI), 2019.
[5]. Bibhuti Bhusan Mukharjee & Sudhirkumar V. Barai, “Influence of Incorporation of Colloidal Nano-Silica on Behaviour of Concrete”, Iranian Journal of Science and Technology, 2020.
[6]. F. Pacheco-Torgal and Said Jalali b, “Nanotechnology: Advantages and drawbacks in the field of construction and building materials”, science direct publications, 2010.
[7]. Oladipupo S. Olafusi, Emmanuel R. Sadiku, Jacques Snyman, Julius M. Ndambuki & Williams K. Kupolati, “Application of nanotechnology in concrete and supplementary cementitious materials: a review for sustainable construction”, Materials Science: Sustainable Building Materials, the Netherlands, 2019.
[8]. N. Silvstre and Jorge de Brito, “Review on concrete nanotechnology”, European Journal of Environmental and Civil Engineering, June 2015.
[9]. Rawa Ahmed and NiyaziUgurKockal, “Nanoparticles used as an ingredient in different types of concrete”, A Springer Nature Journal, April 2021.
[10]. MuhdNorhasriMuhdSidek, marshahamidah and MohdFadzil Arshad, “Applications of using nano material in concrete: A review”, Research gate journal, February 2017.
[11]. Sen Du, Junliang Wu, Othman AlShareedah, and Xianming Shi, “Nanotechnology in Cement-Based Materials: A Review of Durability, Modeling, and Advanced Characterization”, MDPI Publications, August 2019.
[12]. Decheng Feng, NingXie, Chunwei Gong, Zhen Leng, Huigang Xiao, Hui Li and Xianming Shi, “Portland Cement Paste Modified by TiO2 Nanoparticles: A Microstructure Perspective”, ACS Publications, July 2013.
[13]. Premjeet G. Jadhav, K. B. Mahajan, V. R. Khadse and A. J. Chaudhari, “Nanotechnology around Human life: A Review” , Journal of Engineering Science, April 2020.