International Journal of Advance Research in Science and Engineering
Volume No. 11, Issue No. 04, April 2022
www.ijarse.com
IJARSE
ISSN 2319 - 8354

To Investigate Effect of Metakaolin and Colloidal Nano SiO_2 on Properties of Concrete

Mr. Baliram. R. Warvate[1], Dr. Satish S. Deshmukh[2]
Mr. Vaibhav V. Augad[3]

[1] Assistant Professor Civil Engineering Department, Trinity Academy of Engineering, Pune, India
[2]Professor in Civil Engineering Department, Trinity Academy of Engineering, Pune, India
[3]Assistant Professor Civil Engineering Department, Trinity Academy of Engineering, Pune, India

Abstract

In this paper the results of an experimental investigation on the use of Metakaolin (MK) and Colloidal Nano-Silica (CNS) on various properties of concrete are presented. Metakaolin and Colloidal Nano Silica are used as partial replacement of cement for the preparation of concrete. In the present investigation, Metakaolin as a partial replacement with cement was done at 0%, 6%, 12%, 18%, and 24%. Along with the Nano silica Particles 0%, 1%,2%,3%,4% and 5% by weight.For structural applications the various properties, such as compressive strength, durability, Permeability of concrete and porosity of M_{40} grade concrete containing MK and CNS are evaluated and the results are compared with the controlled concrete. Based on the test results, it can be observed that concrete prepared with a combination of 6% MK and 2% NS indicated increased strength compared to the controlled concrete. Hence, it can be concluded that concrete prepared with 6% MK and 1% NS combination can be recommended for the structural applications. The increase in the strength properties of concrete is due to the availability of additional binder in the presence of MK and CNS.

Key Words: Metakaolin, Colloidal Nano Silica, M_{40} grade concrete.

I. INTRODUCTION

The cement industry is considered to be one of the most energy consuming industries, with a high rate of carbon dioxide (CO_2) emissions. Every year, it is responsible for approximately 5.6% of the global manmade CO_2 emissions; 50% of these emissions are caused by chemical manufacturing processes and 40% are due to burning fuel. Extensive research efforts have been directed to reducing the effect of the cement industry on greenhouse gases either by improving the efficiency of the cement manufacturing process or by using supplementary cementitious materials, which partially replace ordinary cement. Various supplementary cementitious materials have been investigated, including fly ash, ground granulated blast furnace slag, natural pozzolans, and silica fume. Recent studies have indicated that the use of new technologies may lead to industrial breakthroughs for the manufacture of supplementary cementitious materials. It is believed that nanotechnology is one of the most promising research fields that may significantly improve the mixture design, as well as the performance and production of cement-based materials.

The mechanical behavior of concrete materials depends to a great extent on structural elements and phenomena that are effective on a micro- and Nano scale. The size of the calcium silicate hydrate (C-S-H) phase, the primary component responsible for strength and other properties in Cementitious systems, lies in the few nanometers range. The structure of C-S-H is much like clay, with thin layers of solids separated by gel pores filled with interlayer and adsorbed water. This has significant impact on the performance of concrete because the structure is sensitive to moisture movement, at times resulting in shrinkage and consequent cracking if accommodations in element sizes are not made. Hence, nanotechnology may have the potential to engineer concrete with superior properties through the optimization of material behavior and performance needed to significantly improve mechanical performance, durability, and sustainability.

II. LITURATURE SURVEY

The extensive literature review was carried out by referring standard journals, reference books, I.S. codes and conference proceeding. The major work carried out by different researchers is summarized below The

IJARSE
ISSN 2319 - 8354

Researcher carried out experimental investigation on the use of Metakaolin (MK) and Nano Silica (CNS) on various properties of concrete are presented. Metakaolin and Nano-Silica are used as partial replacement of cement for the preparation of concrete. In the present investigation initially cement is partially replaced by Metakaolin 5% and 10% by weight. Further investigation is carried out by combined replacement of Metakaolin at 5% and 10% with Nano-Silica at 1%, 2% and 3% by weight of cement. For structural applications the various properties, such as compressive strength, split tensile strength, modulus of elasticity and flexural strength of M_{25} grade concrete containing MK and CNS are evaluated and the results are compared with the controlled concrete. Based on the test results, it can be observed that concrete prepared with a combination of 5% MK and 2% NS indicated increased strength compared to the controlled concrete. The Researcher concluded that concrete prepared with 5% MK and 2% CNS combination can be recommended for the structural applications. The Increase in the strength properties of concrete is due to the availability of additional binder in the presence of MK and CNS. [1] The use of metakaolin as a partial replacement for cement decreased the plastic density of the mixtures. The results shows that by utilizing local metakaolin and Cement designed for a low water/binder ratio of 0.3 High strength and high performance concretes can be developed and compressive strengths of more than100 Mpa can be realized. The optimum replacement level of OPC by metakaolin was 10 %, which gave the highest compressive strength in Comparison to that of other replacement levels; this was due to the dilution effect of partial cement replacement. These concretes also exhibited a 28-day splitting tensile Strength of the order of 5.15 % of their compressive Strength and showed relatively high values of modulus of elasticity. Splitting tensile strengths and elastic Modulus results have also followed the same trend to that of compressive strength results showing the highest values at 10 % replacement. As far as the durability properties are concerned, local metakaolin found to reduce water permeability, absorption, and chloride permeability as the replacement percentage Increases. [2]

III. RESULT AND DISCUSSIONS

The specimens are tested under the compression testing machine after 3, 7 and 28 days of curing.

CNS %	MK %	Strength After 3 Days	Average Strength After 3 Days	Strength After 7 Days	Average Strength After 7 Days	Strength After 28 Days	Average Strength After 28 Days
		13.70		24.00		42.30	
	0	14.10	14.23	25.30	25.30	39.20	40.27
		14.90		26.60		39.30	
		13.60		29.10		41.20	
	6	15.60	15.47	24.70	27.00	42.20	41.33
		17.20		27.20		40.60	
		11.30		29.50		39.30	
0	**12**	12.40	12.97	25.40	26.97	39.80	39.67
		15.20		26.00		39.90	
		9.30		27.10		39.50	
	18	11.20	10.33	25.30	24.90	34.60	37.10
		10.50		22.30		37.20	
		8.50		16.50		36.20	
	24	12.10	9.97	18.30	17.37	37.20	35.97
		9.30		17.30		34.50	
		13.10		29.10		42.20	
	0	14.20	13.73	31.20	30.17	41.30	41.83
		13.90		30.20		42.00	
1		**16.40**		**32.00**		**42.50**	
	6	**15.30**	**16.07**	**35.00**	**34.03**	**41.90**	**42.67**
		16.50		**35.10**		**43.60**	
	12	16.20	14.43	31.30	31.23	39.10	40.43
		13.90		30.80		44.00	

IJARSE
ISSN 2319 - 8354

		13.20		31.60		38.20	
	18	12.10	12.63	24.00	25.43	38.20	38.57
		12.40		24.30		38.00	
		13.40		28.00		39.50	
	24	11.20	10.90	20.30	20.30	35.50	36.67
		12.30		22.30		38.20	
		9.20		18.30		36.30	
2	0	11.90	13.33	20.10	21.83	39.20	39.73
		13.80		22.20		38.90	
		14.30		23.20		41.10	
	6	12.30	13.40	27.10	27.50	40.10	39.50
		14.30		27.30		39.70	
		13.60		28.10		38.70	
	12	14.10	13.17	24.60	25.20	39.40	38.30
		13.90		25.30		39.20	
		11.50		25.70		36.30	
	18	14.00	11.60	22.10	22.27	40.10	37.83
		11.80		20.20		38.20	
		9.00		24.50		35.20	
	24	9.20	10.27	18.20	17.90	39.20	36.57
		10.30		19.10		34.30	
		11.30		16.40		36.20	
3	0	10.00	10.50	20.20	19.80	38.70	36.80
		9.20		18.10		34.90	
		12.30		21.10		36.80	
	6	10.90	11.97	24.60	25.20	37.30	36.67
		11.50		24.50		36.50	
		13.50		26.50		36.20	
	12	13.20	12.20	25.20	24.03	37.20	36.37
		11.30		22.30		35.10	
		12.10		24.60		36.80	
	18	8.30	9.57	22.20	21.20	34.60	34.70
		9.50		19.50		36.20	
		10.90		21.90		33.30	
	24	7.50	8.83	18.30	17.47	30.90	33.03
		8.90		17.60		36.40	
		10.10		16.50		31.80	
4	0	10.10	10.40	19.40	18.17	36.90	36.47
		11.30		16.90		35.90	
		9.80		18.20		36.60	
	6	11.10	11.97	29.10	24.57	35.90	36.30
		11.60		24.30		38.20	
		13.20		20.30		34.80	
	12	9.80	10.43	24.50	21.60	36.80	34.03
		11.20		18.10		34.30	
		10.30		22.20		31.00	
	18	9.60	10.03	20.40	20.87	36.20	33.73
		11.60		20.00		34.10	
		8.90		22.20		30.90	
	24	8.90	9.80	18.20	16.80	34.10	31.47
		9.00		15.90		30.20	

		11.50		16.30		30.10	
5	0	11.90	11.27	16.30	17.87	35.90	34.80
		12.40		18.20		33.70	
		9.50		19.10		34.80	
	6	12.50	11.53	22.30	23.90	27.20	34.47
		11.20		25.20		37.10	
		10.90		24.20		39.10	
	12	9.30	11.30	18.30	20.83	36.90	33.67
		12.30		23.20		29.30	
		12.30		21.00		34.80	
	18	9.60	11.00	21.10	20.77	35.10	33.57
		14.20		19.20		36.30	
		9.20		22.00		29.30	
	24	11.10	10.33	15.30	16.40	29.70	31.23
		10.00		18.50		29.90	
		9.90		15.40		34.10	

IV. CONCLUSION

Controlled concrete of M_{40} Grade is prepared and tests were conducted on standard concrete specimens to obtain compressive strength and the results are compared with concrete containing various combinations of Metakaolin 0%, 6%, 12%, 18% and 24% along with Colloidal Nano-Silica 0%, 1%, 2%, 3%, 4% and 5% as cement replacement. Using the test results, it can be concluded that for a given Metakaolin content, the compressive strength of concrete for 3, 7 and 28days of curing increases as the percentage of Metakaolin is increased up to 6% and 1% of Colloidal Nano cilica then decreases with increase in Metakaolin content. The higher surface area of Metakaolin yielded the highest strength and the fastest rate of strength gain.

The increase in the strength of concrete containing Metakaolin and Nano-Silica can be attributed to the availability of additional binder. Nano-Silica has high amorphous silicon dioxide content and is a very reactive pozzolanic material. As the Portland cement in concrete begins to react chemically, it releases calcium hydroxide. The Nano-Silica and Metakaolin reacts with the calcium hydroxide to form additional binder material.

It can be concluded that, the various strength properties of concrete can be improved by the addition of a specified percentage (1%) of Nano-Silica and (6%) of Metakaolin content.

REFERECNES

1) Dr. D. V. Prasad Rao, S. VenkataMaruthi,**"**Effect of Nano-silica on concreteContaining Metakaolin",International Journal of Civil Engineering and Technology (IJCIET**)** Volume 7, Issue 1, Jan-Feb 2016.
2) Dinakar, Pradosh K. Sahoo, and G. Sriram, "Effect of Metakaolin Content on the Properties of High StrengthConcrete", International Journal of Concrete Structures and Materials Vol.7, No.3, pp.215–223.
3) Alaa M. Rashad, "Metakaolin: fresh properties and optimum content for mechanical strength in traditional cementitios materials a comprehensive overview", Building Materials Research and Quality Control Institute, Housing & Building National Research Center,EgyptReceived: March 08, 2014.
4) Ana Luisa Velosa, Fernando Rocha and RosárioVeiga, "Influence Of Chemical And Mineralogical Composition Of Metakaolin On Mortar Characteristics", Geo-BioTech Research Centre, Civil Eng. Dep., University of Aveiro, 3810-193 Aveiro, Portugal GeoBioTec Research Centre, Geosciences Dep., University of Aveiro, 3810-193 Aveiro, Portugal LNEC, National Laboratory of Civil Engineering, 1700-066 Lisboa, Portugal Vol. 6, No. 1 (153), 121–126, 2009.