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Silica Nanoparticle Modified Concrete: A Review

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Abstract: Due to rapid growth and development of construction industry, Portland cement is used as primary binding material. The main environmental issue connected with the production of ordinary portland cement is the emissions of carbon dioxide which is due to the combustion of fossil fuels and calcinations of lime stones. Reduction in the usage of portland cement will reduced the demand of portland cement hence reduction in the emissions of carbon dioxide will occur. Many researchers try to modify the concrete using subsidiary cementeneous materials which will be helpful for both environment and enhancing the strengthening properties of concrete. A number of R & D work dealing with the use of nano materials like Nano silica, colloidal Nano Silica (CNS), Al2O3, TiO2, ZrO2,Fe2O3, carbon nano tubes in cement based composite material are discussed in the present study. Based on the outcomes of the literature reviewed in the present study, it can be concluded that silica nanoparticle, when partial replaced with cement in small amount, has the ability to improve the mechanical properties of concrete.
Keywords: Concrete, Cement, Carbon dioxide, Nanomaterial, Mechanical Properties

I. INTRODUCTION

Due to rapid growth and development of construction industry, the demand of concrete is increasing day by day. In any developing country, the major initiative infrastructures are bridges, highways, airports, power projects etc. essential to cope up with the requirement of globalization. For construction of any infrastructure, concrete plays a vital role but concrete is major source of carbon emission because approximately 10% of carbon dioxide emissions are generated from the production and transportation of concrete. In recent, according to various researchers' production of one ton of Portland cement generates one ton of carbon dioxide in environment. So reduction in the usage of portland cement will reduced the demand of portland cement hence reduction in the emissions of carbon dioxide will occur. Some researchers try to modify the concrete using subsidiary cementeneous materials like silica nanoparticle which will be helpful for both environment and enhancing the strengthening properties of concrete.

II. SILICA NANO PARTICLES

Silica Nanoparticle (highly reactive pozzolanic material) which is also known as Nano Silica whose size is in nanometers, when used in small amount as partial replacement of cement, these nanoparticles filling the voids in the microstructure of the concrete which prevents the growth of the calcium hydroxide crystal and also react with calcium hydroxide crystals and converting them in C-S-H gel. Reduction in the growth of calcium hydroxide crystal is the main reason for the enhancement of mechanical properties of modified concrete.

III. LITERATURE REVIEW

AlirezaNajiGiviet.al. (2012) investigated the impact of nano silica particles on water absorption of rice husk ash mixed concrete. It is finalized that cement could be partially replaced within 20% by rice husk ash in presence of nano silica particle up to 2% which enhances physical and mechanical properties of concrete.

J. Comilettiet. al. (2012) studied the impact of micro and nanoCaCO3 on the early age strength properties of Ultra-HPC cured in normal and cold field conditions. The micro CaCO3 was mixed from 0 to 15% by w.c. and nanoCaCO3 was added in the proportion of 0, 2.5% and 5% by w.c. Results revealed that by addition of micro and nanoCaCO3 the flow ability of Ultra-HPC is greater than that of control mix which increases the cement replacement level. The mixture containing 5% nanoCaCO3 and 15% micro CaCO3 gives shortest setting time at 10 °C and at20°C the highest 24 hrs compressive strength is achieved by replacing cement with 5% micro & 2.5% nano CaCO3 highest compressive strength at 26 dayss was achieved at 0% nano and 2.5% micro CaCO3.

G. Dhinakaranet. al. (2014) studied the strength characteristics of concrete & microstructure with Nano SiO2. The silica was grind in the ball mill till it reached nano size and it was mixed in concrete from 5% to 15% in a multiple of 5% b.w.c.. The experiment results revealed increase in compressive strength with maximum strength at 10% replacement.

Barai and Mukharjee (2014) studied the properties of Interfacial-TZ (aggregate paste interface) and compressive strength of concrete having recycled aggregate and nano-silica. An improvement in the microstructure & in the compressive strength was recorded with the addition of nano-silica.

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S. Tanveer Hussain (2015) written in his paper that the useage of large amount of cement produces more carbon dioxide emissions and generate green house effect. A method to minimize the cement amount in concrete mix is the addition of silica fume which is non-crystalline polymorphs of silica. It is very fine powder gathered as by product of the ferrosilicon and silicon alloy produced with an average particle diameter of 0.1 to 0.5 µ. The previous studies revealed that silica fume was an excellent pozzolanic material for the manufacturing of HP concrete. In this study strength properties like Compression, split tension and flexure strength of M40 and M50 grades of concrete with the use of micro silica (5%, 7.5%, 10%, 15%) and nano silica (1.0%, 1.5%, 2.0%, 2.5%) as partial replaced. It was reported from the investigation that concrete composites with superb properties can be manufactured using nano silica, micro silica and combination of nano silica and micro silica.

Kavitha and Sandhiyadevi (2016) investigated the effect of NS on the mechanical and durability and flexural properties of concrete. From the present investigation the performance of nanosilica concrete with and without flyash was studied and they were compared to the performance of control mix. Fresh properties of the concrete were determined by carrying out the workability test, compacting factor, veebee, and flow test. The mechanical properties are determined by split tensile strength, compressive strength, modulus of elasticity, impact resistance and flexural strength. The durability properties are determined by acid attack test, sulphate attack test, bulk diffusion test. The behavior of nanosilica beam under flexure was also studied by 2 point loading flexure test.

DariushHajizadehAsl (2016) said that concrete is the world's largest adopted building material in several civil engineering applications and therefore, any attempt to increase efficiency regarding the process of its

production can lead to a high level of economic benefit. The most important challenge in using concrete is to improve its mechanical properties as well as its durability in different applications. Nano-silica has gained a lot of attention as an additive agent to the cement for production concrete due to its improving influence on mechanical properties and durability of the concretes. The present review summarized part of studies on the effect of NS on concrete; however, it seems that there should be more research to find out other effect of Nanosilica in concretes and proper dosage for various applications in different environments.

Nihat and Layth (2017) studied on the influence of NS on the durability, gas permeability and mechanical characteristics of HSLWC. In order to find out the impact of NS on the properties of concrete, LWA is fabricated with cold bonded method with process of pelletization by mixing 10% cement with 90% FA. After that the utilization of HSLWC is completed by partial replacement of normal coarse aggregate in a level, i.e. (0 to 40% in a multiple of 10%) without and with NS at constant water/cement ratio 0.35 and constant at ratio of 20% FA. The concrete is examined at a age of 28 & 90 days for splitting tensile strength, gas permeability, sorptivity index. Analysis revealed that the increase in the substitution of LWC aggregate affecting the strength & permeability properties negatively. On the other side, the outcomes explained that 3% nanosilica addition to HSLWC reduce the negative characteristics of LWC aggregate and

tends to remarkable increase in mechanical properties also the gas permeability and sorptivity values are decreased upto 40% and 25% respectively, if the values are compared with the previous substution levels of LWA. However, NS particles have better results on conventional concrete compared to the LWC.

Reddy and Meena (2018) Experimental investigated the utili-zation of FA and Alccofine contributes for the achievement of high strength TBC. It was observed that all TBC mixes with all four grades of NS sets quickly and also achieved high strength when compared with other blended mixes. The increase in com-pressive strength is about 20.699%, 18.3050% and 10.8796% for CN4 mix at 7, 14 and 28 days respectively when compared to CM. it was also found that when the XTXla NS percentage was in-creased to 2%, 3% as additive compressive strength reduced con-siderably. The total substitution of cement by 25% (FA 15% and ALC 10%) brings about reduction in cost resulting in economy. Furthermore the reduction in cement leads to sustainability, since there is reduction in CO2 emission in cement manufacture.

Reddy, Meena, Priyanka and Mounika (2019) analysed that the concrete having addition of FA and NS sets quickly when compared to conventional concrete. Compressive strength test result with FA and NS combination at different ages revealed that the outcomes are superior compared to conventional concrete. In this investigation, the maximum compression strength was developed with the addition of FA & XTXla type NS at 25-1% respectively, it also show highest strength values in split tensile and flexural strength. Addition of substitute materials leads to ecofriendly and sustainable concrete reduce the overall manufacturing cost of the concrete.

IV. CONCLUSION

A number of literature reviews shows the importance of this field of research. The investigation shows that a number of nano materials i.e. Al2O3, TiO2 , SiO2 metakaolin, colloidal nano silica and others can be used to enhance the strengthen properties of concrete. The examination shows the enhanced strength characteristics of the mixed concrete in terms of compression, flexural and tensile strength. But the permeability of the sample can also be enhanced by adding a very small percentage of the nanomaterial.

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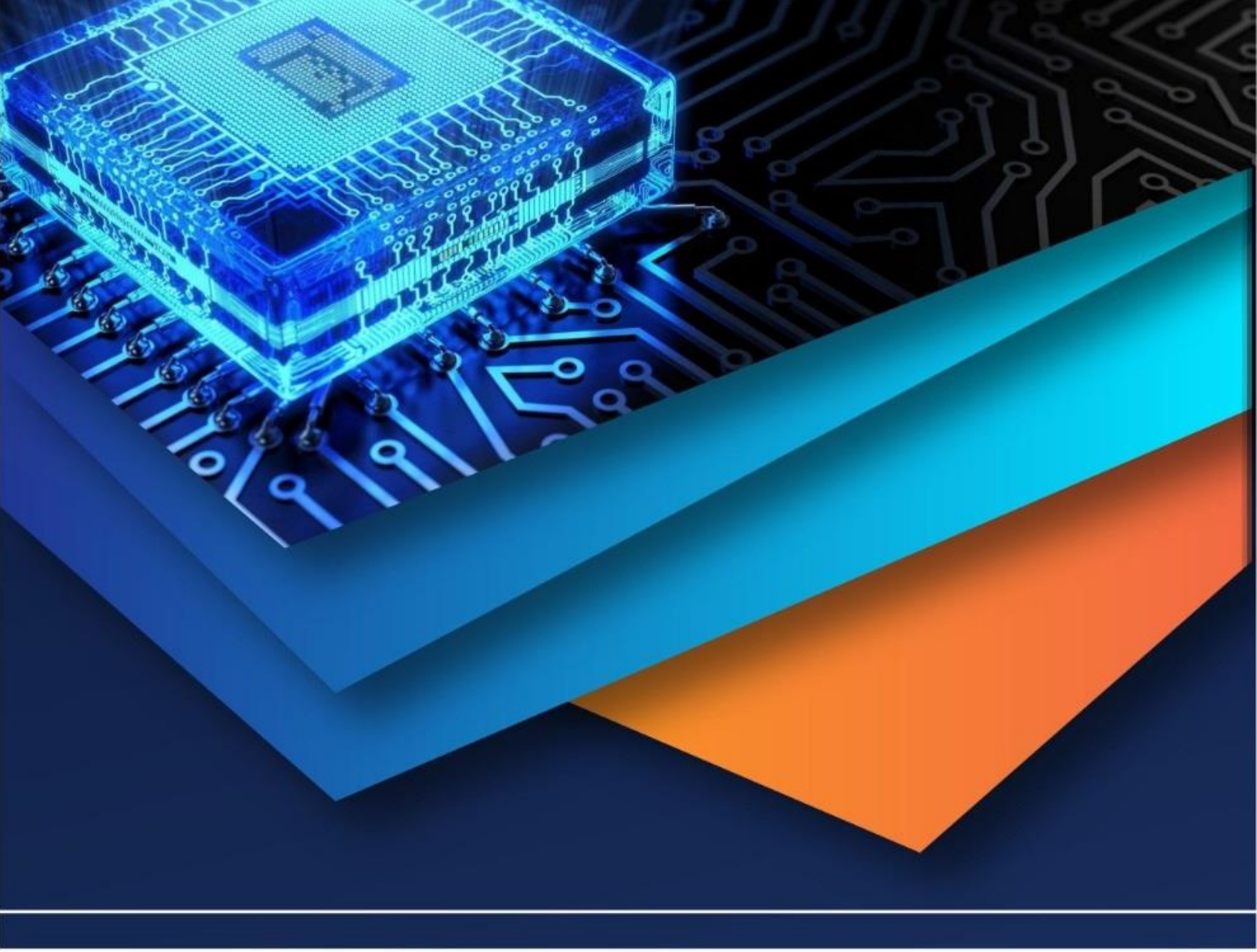

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