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Experimental Study on Mechanical Properties of Concrete by Replacement of Cement with SCBA and Nano Silica

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Abstract: ***In this study the mechanical and durability properties of concrete were investigate containing sugarcane bagasse Ash (SCBA) and Nano silica .Concrete mix with the design water cement ratio in addition of SCBA and Nano silica have reviewed. For experimental study test specimen were prepared with 1% to 5% of replacement of cement weight with Nano silica and 5% to20% replacement of cement weight with sugar cane bagasse ash (SCBA).SGBA is by product of sugar industries, which led so many environmental concerns Influence of Nano silica and sugar cane bagasse ash (SCBA) on the mechanical and durability properties of concrete are investigated in this study. A compressive strength test was conducted to evaluate the mechanical performance of concrete containing Nano silica and SCBA. In addition, temperature test, Split tensile test, Flexural test and Modulus of elasticity test on performed to investigate the influence of replacement materials on mechanical properties of concrete. As Nano silica improves mechanical properties of concrete, while SCBA have a substantial influence on concrete performance according to strength at early ages. The addition of SCBA in mixtures containing Nano silica intensely increases compressive strength at the early age.***

Keywords: Nano Silica, Sugar cane bagasse ash (SCBA), Compressive strength, Mechanical properties, pozzolanic material

I. INTRODUCTION

The demand of concrete is increasing day by day for the need of development of infrastructure facilities. Concrete is one of the most essential materials used in construction field. Ordinary Portland Cement (OPC) is used as the primary binder to produce the concrete. However, it is well known that the production of cement (OPC) not only consume huge amount of natural resources but also releases substantial quantity of carbon dioxide to the atmosphere. According to US government statistics, it is estimated that in 2018 alone, 4.1 billion tons of OPC was produced worldwide. The idea of partially replacing OPC by other materials can be supported by the fact that there is an enormous amount of waste such as Fly ash, GGBS, RHA and Bagasse ash (SCBA) are widely used in industrial by-products in concrete which possesses excellent mechanical properties with enhanced durability performance.

Substantial to the awareness regarding environmental unbalance due to production of cement, a new notion has been emerged to produce concrete and mortar devoid of cement, famed as Sugarcane which is one of the major crops grown in over 110 countries and its total production is over 1500 million tons. After the extraction of all economical sugar from sugarcane, about 40-50 % fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat or power generation leaving behind 8 -10 % ash as waste, known as sugarcane SCBA. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50% and 0.62% of residual ash) the residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2). The major oxide observed in SCBA is silica (SiO2), which is about 77.25%, the total summation of SiO2 + Al2O3 + Fe2O3 is 87.83%, the calcium oxide, CaO is 4.05%, and hence this ash classifies as class F pozzolanic according to ASTM C 618 (2009). The X-Ray Diffraction (XRD) analysis of the SCBA shows the amorphous silica formation with traces of low quartz.

Fig. 1 Sample of Sugarcane bagasse & Nano-Silica

While the meaning of "Nanotechnology" varies from field to field and country to country as is widely used as "catch all" description for anything very small, nanotechnology is commonly defined as the understanding, control, and restructuring of matter on the order of nanometres i.e. less than 100 nm to create materials with fundamentally new properties and functions.

II. METHODOLOGY

Research consist preparation of concrete specimens such as cubes, beams, & cylinder with partial replacement of sugarcane bagasse (SBCA) & silica with cement. All the ingredients are used as per pertaining to their required standards in terms of mechanical properties, physical properties, chemical properties, shape & size, texture & source. Further the concrete mix was designed for proportions by '*Indian Standard method for Concrete Mix Design'* considering the substitution of sugarcane bagasse by 5%, 10%, 15%, and 20% by volume in place of cement making considerations with respect to the specific gravities of material. Only the new material i.e. by product of Sugarcane i.e. SCBA & Nano-Silica are selected on the basis of specifications published in earlier studies & their properties are shown in below table-I & I

TABLE – I
Chemical Properties Bagasse Ash

Sr. No	Chemical compound	Abbreviation	%
1.	Silica	Sio_2	68.42
2.	Aluminum oxide	Al_2O_3	5.812
3.	Ferric Oxide	Fe_2O_3	0.218
4.	Calcium Oxide	CaO	2.56
5.	Phosphorous Oxide	P_2O_5	1.28
6.	Magnesium Oxide	MgO	0.572
7.	Sulphide Oxide	SO_3	4.33
8.	Loss on Ignition	LOI	15.90

TABLE – II
Properties of Nano-Silica

Sr. No	Characteristics	Value obtained
1.	Parameter	CemSynXTX
2.	Active Nano content	30 – 32%
3.	pH(20 ° C)	9 – 10
4.	Specific Gravity	1.20 – 1.22
5.	Particle Size	5 – 40 nm

Table – III
Mix Proportion for trial

Sr. No	Description	Results
1.	Cement	383.16 kg/m^3
2.	Fine Aggregate	685.75 kg/m^3
3.	Coarse Aggregate	1157.55 kg/m^3
4.	Water-Cement ratio	0.50
5.	C : FA : CA	1 : 1.789 : 3.02

III. RESULTS AND DISCUSSION

A. RESULTS

Each proportion was tested for five different consisted of slump cone test on fresh concrete and compressive strength test, splitting tensile strength test, flexural strength or modulus of rupture, static modulus of elasticity test and Temperature test on hardened concrete which were conducted on the specimens after removing the specimens from curing tank after specified curing period as 7, 28, 56 days as shown below.

1. Slump cone test

The slump cone test is used to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of work. The effect of Nano Silica and SCBA on workability of concrete for various mixtures is given below in graph as Fig. 2.

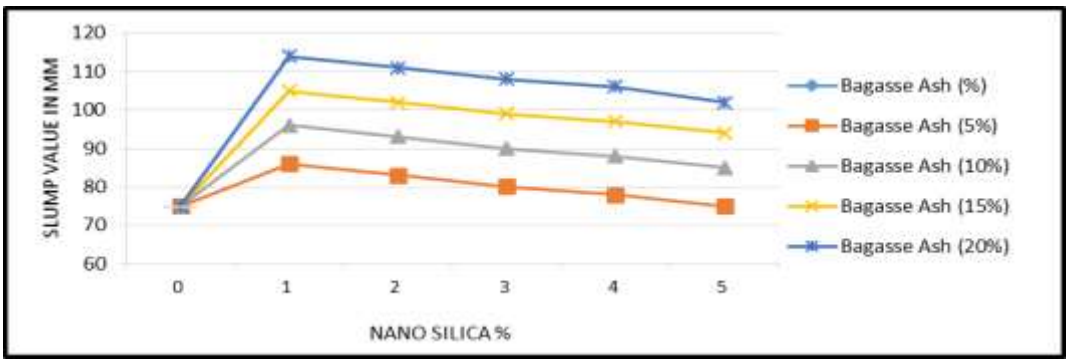

Fig. 2 Graph showing average slump cone values of all mixe

2. Compressive strength test

The effect of Nano Silica and SCBA on compressive strength of concrete for various mixtures is given below in fig. 3.

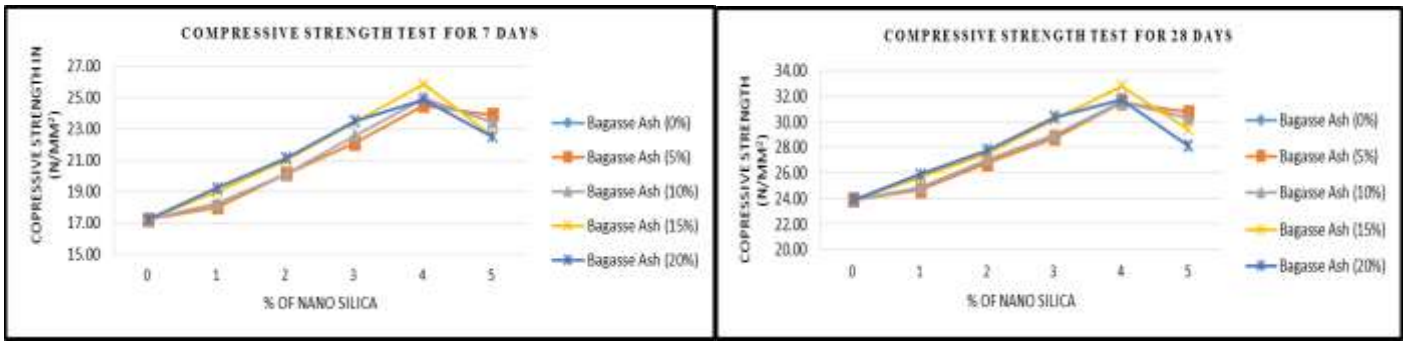

Fig.3 Graph showing compressive strength for 7 & 28 days respectively of concrete

3. Split Tensile Test

Splitting tensile strength is used to determine the tensile strength of concrete in an indirect way which shown in Fig. 4 below.

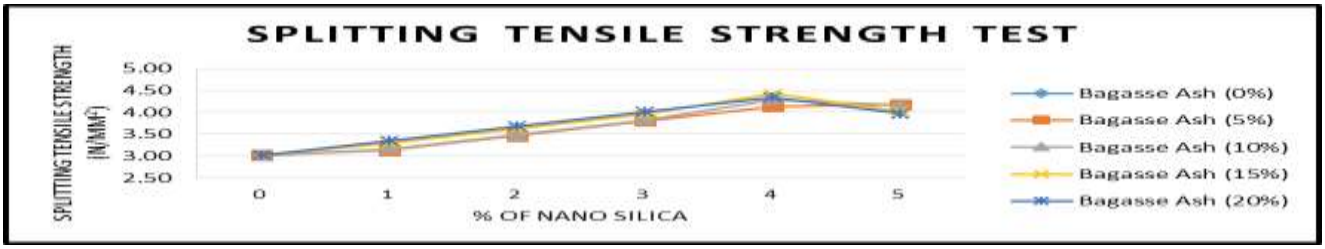

Fig.4 Graph showing Split Tensile Strength of concrete

4. Flexural Test

The effect of Nano Silica and SCBA on flexural strength of concrete for is shown in Fig. 5 below.

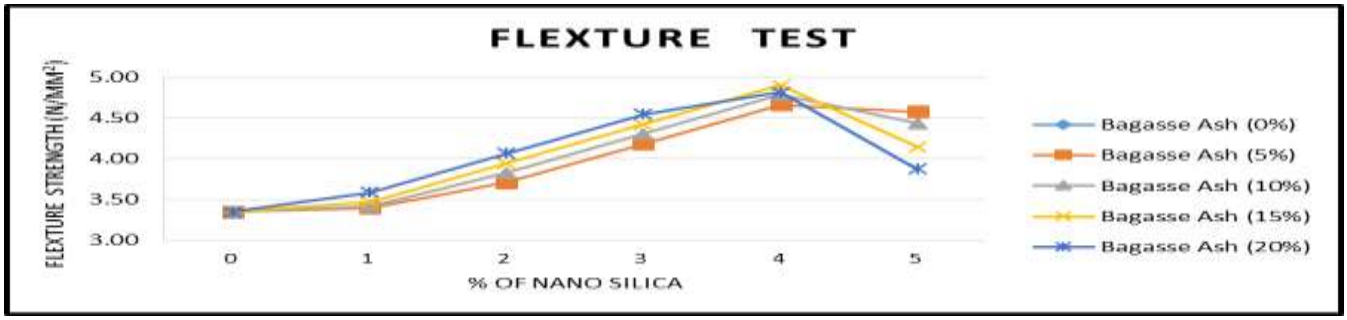

Fig. 5 Graph showing Flexural Strength of concrete

5. Modulus of Elasticity Test

The effect of Nano Silica and SCBA on modulus of elasticity of concrete for stiffness is shown in Fig. 6 below.

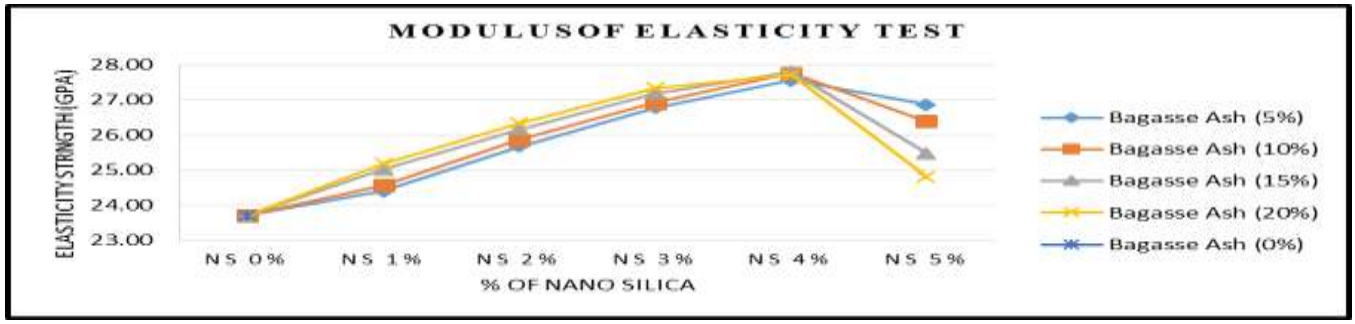

Fig. 6 Graph showing Modulus of Elasticity Property of concrete

CONCLUSION

Research proposes the effective utilization of sugarcane bagasse (SCBA) & Nano-silica as substitute for cement, thus eminently expressing the mode of reducing CO_2 emission and degradation of environment due to continuous increase in non-decomposable wastes. After studying the several test results of different specimens ranging in Nano Silica and SCBA content from 0% to 5% and 0% to 20% respectively in replacement of Cement, the following conclusions are made:

1. The workability of concrete improves due to addition SCBA and is acceptable in terms of the ease in handling, the placing and finishing of wet concrete as compared to normal concrete.
2. The dry density and compressive strength of concrete reduces as the percentage of SCBA content increases at the time it is increases as Nano silica is increases.
3. Good compressive strength was recorded at Nano Silica and SCBA contents at the mix Nano Silica 4% and SCBA 15%. Further addition of Nano Silica 4% and SCBA 20%. Then strength is decreased in replacement of Cement.
4. The splitting tensile strength, flexural strength and of concrete increases as the Nano Silica and SCBA percentage increases at 4% NS and 15% SCBA further it decreases.
5. Although the strength of concrete is reduced with increase in Nano Silica and SCBA content, its lower unit weight meets the criteria of light weight concrete.
6. This is an ultimate solution of minimum use of cement and their production which will help to reduce the CO_2.

FUTURE SCOPE

The present study of substituted sugarcane Nano- silica concrete shows the significant potential to be a material for the future, because it is not only environment friendly but also possesses the required strength and durability. However It is recommended that the future research should be perform to evaluate the use of SCBA and Nano silica in concrete as a replacement of cement material. As well, future studies required on following issues.

1. Durability
2. Mechanical Properties of with the use of chemical admixture.
3. Working on cost analysis.
4. Sustainable aspect with use of Nano silica and bagasse ash.

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