Effect of Nano Silica in Rice Husk Ash Concrete

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***Abstract*— A Concrete is the most commonly used material for construction and their design consumes almost the total cement production in the world. Concrete is vulnerable to deterioration, corrosion & cracks. The use of large quantity of cement leads to increasing CO_2 emission and as a consequence, the greenhouse effect. A method to reduce the cement content in concrete mixes is the use of Silica fines. However, the commercial NS is synthesized from rice husk ash (RHA). This work presents a laboratory studies on the preparation of rice husk ash by burning at 700^0c for 3h.Consequently, silica content obtained after heat treatment is 90.3%.SEM results shows that 2.5N NAOH for 3h provided agglomerate particles with dimension 5-10nm.As the burning process strongly affects the pozzolanic activity of produced RHA, in some cases RHA concretes suffer low initial strength. Integrating NS with RHA in concrete Seems to be beneficial to overcome this problem. However, an effort is to be made to investigate the effect of Nano silica (NS) in improving the properties of RHA concrete. Accordingly 0.5%, 0.75%, 1% NS is incorporated into RHA concrete. The amount of RHA was 20%, (by Weight of cement) which is an acceptable range and is most often used. The compressive and Flexural strength tests are to be carried out at 28 days.**

Index Terms*— Nano Silica, RHA, SEM, NaOH.

I. INTRODUCTION

Nano technology has gained increasing scientific interest due to the new potentials of using Nano scale particles. The Nano size particles show unique physical and chemical properties as a result of their fine size [1]. Pozzolanic reaction is proportional to the amount of surface for reaction and owing to the high specific surface of Nano sio_2 particles, they possess high pozzolanic activity[2].Filling the voids of CSH gel structure and generating homogenous distribution of the hydrated products beside reduction the quantity of big and porous portlandite macro crystals are mainly responsible for Mechanical strength improvement caused by Nano sio_2 [3].It has been found that when the small particles of Nano sio_2 uniformly disperse in the paste due to their high activity generate a large number of the nucleation sites for the precipitation of the hydrated products accelerating cement hydration [3].

As more than 650 million tons of rice paddy has been produced in 2008 all around the globe. As one fifth of paddy is husk, total production of rice husk is 200million tones [FAO statistical Data base 2008].Because Rice Husk ash in its raw form has a limited application, in the majority of rice producing countries (mostly under developed countries) much of the husk produced from the processing of rice is burnt or dumped as a waste which creates a serious environmental problem. One main use of RHA has been identified as a pozzolan in cement industry [4].It has been demonstrated that Rice Husk Ash (RHA) can be added to concrete mixtures to substitute the more expensive Portland cement to lower the construction cost.

II. APPLICATION OF NANO SILICA

Nano silica is applied in HPC and SCC concrete mainly as an anti-bleeding agent. It is also added to increase the cohesiveness of concrete. It reduces the segregation tendency.Nano silica fills the voids in the young and hardened state. The addition of 1kg of micro silica permits the reduction of about 4kg of cement. It can improve the microstructure and reduce the water permeability of hardened concrete [5].Nano silica application reduces the calcium leaching rate of cement pastes and therefore increases their durability.NS addition increases density, reduces porosity, and improves the bond between cement matrix and aggregates.

III. ADVANTAGES OF INTREGRATING NANOSILICA WITH RHA

It can enhance the long term and short term strength of high volume and high strength concrete. Nano silica can potentially improve the negative influences caused by the Rice hush ash on the early strength of mortar. By combining two components with different particles size distribution can increase the packing density [6]. Nano silica can increase the pozzolanic activity of other pozzolans which have low initial activity. It reduces the porosity of cement matrix which plays a vital role in mechanical strength.

IV. SYNTHESIS OF PURE SILICA FROM RICE HUSK ASH

Ten grams of RHA is stirred in 80ml distilled 2.5N Sodium hydroxide solution respectively.RHA was boiled in a covered 250ml Erlenmeyer Flask for 3 h. The solution was filtered and the residue was washed with 20ml boiling water. The filtrate was allowed to cool down to room temperature and added 5N H2SO4 until the pH 2 and then added NH4OH until pH 8.5 allowed at room temperature for 3.5 h. The filtrate was then dried at 1200 C for 12h.As the received product is to be finally investigated by Fourier Transform Method.

V. MORPHOLOGY OF NANOSILICA

Particle size and morphology of synthesized silica were examined by TEM (Joel, JSM2010) using a 200 keV electron beam on the sample mounted on a carbon coated copper grid. With the assumption of spherical shape, the size of the particle is determined from the number averaged particle radius. Silica sample (10mg) was sonicated for 3h in isopropyl alcohol (5ml).About 50ml of the silica suspension was taken using a dropper and spread on the carbon coated copper grid and allowed to dry in room temperature. The copper grid was introduced into the instrument and the sample chamber was evacuated. The sample was scanned along the path of the electron beam and photograph of the sample was taken at 200,000 magnifications.

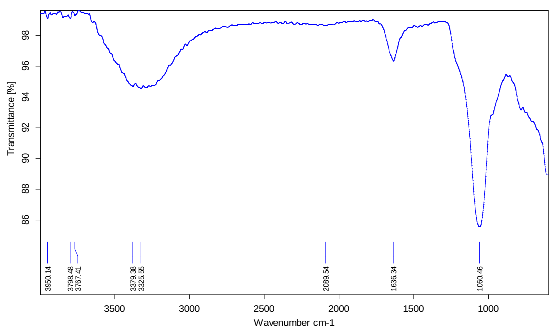
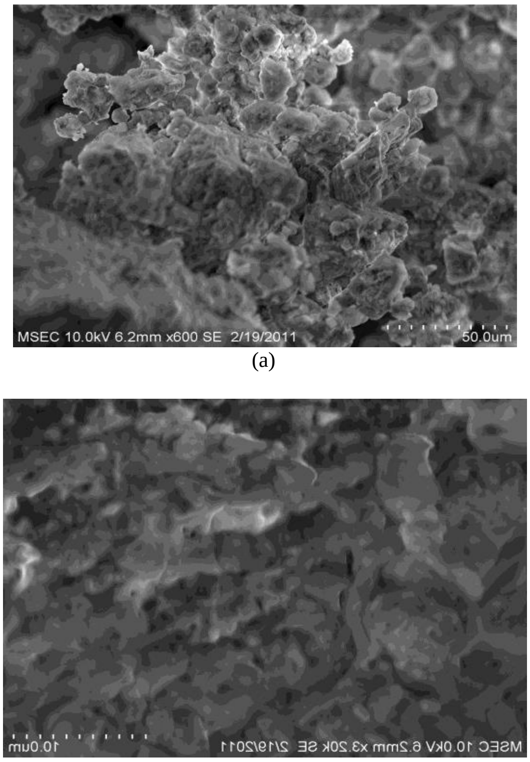


Fig. 1. Fourier transform infrared spectra of spectra of pure silica produced from RHA

VI. EFFECT OF CONCENTRATION OF SODIUM HYDROXIDE ON NANOSILICA PRODUCTION

The particle size of the nanosilica after treated by 2.5N Sodium hydroxide was determined by SEM. Sodium hydroxide had an effect on the particle size and specific surface area of the nanosilica.SEM micrographs showed that the particle sizes are in nanometer scale with in agglomeration form. The shape of the particle was found to be uniform and agglomerated species. The amorphous phase of the main phase was shown in fig. 2



(a)

(b)

Fig. 2. SEM micrograph and diffraction pattern of samples (a) treated by 2.0N NAOH (b) treated by 3.0N NAOH

VII. MATERIAL PROPERTIES

In this study, Ordinary Portland cement type of 53grade,standard graded sand, rice husk ash, nanosilica particles and tap water were used.RHA used in this experiment contained 92.1% SiO_2 with average diameter of 15.83µm. The chemical composition of RHA and cement were analyzed using an X-ray microprobe analyzer (Table 1).Coarse aggregate was crushed rock with a maximum size of 20mm and a specific gravity of 2.70.The fine aggregate was natural sand with a fineness modulus of 2.35 and a specific gravity of 2.50.Basic material properties of nanosilica are given in Table2.

TABLE I
CHEMICAL COMPOSITION OF RHA AND CEMENT

Item	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	SO_3 (%)	L.O.I (%)
Cement	21	4.6	3.2	64.5	2	2.9	1.5
RHA	92.1	0.41	0.21	0.41	0.45	-	1.5

TABLE II
BASIC MATERIAL PROPERTIES OF NANO SILICA (IN POWDER FORM)

Composition (mass %)	93.15
Particle size(nm)	5-10
Specific Surface area(m^2g)	656

VIII. MIX PROPORTIONS

ACI Mix Design (Sheety M.S.1980) was used to achieve a mix with a compressive strength of 25Mpa.The water Cement Ratio0.43and the proportion of cement: fine Aggregate: Coarse Aggregate for the mix is 1:1.137:2.38, considered in this study.

IX. STRENGTH TESTS

Following are the tests conducted for evaluating the strength properties of Nanosilica incorporating with Rice husk ash concrete
A) Compressive Strength Test
B) Flexural Strength Test

A) Compressive Strength Test

150mmx150mmx150mm concrete cubes were casted using 1:1.137:2.38 mix with W/C ratio of 0.43 specimens with Portland pozzolana cement and PPC replaced by rice husk ash at 20% replacement and 0.5%,0.75%,0.1% nanosilica is used as a concrete additive were cast.During casting, the cubes were mechanically vibrated. After 24 hours the specimens were removed from the mould and subjected to water curing for 7 and 28 days. After specified period of Curing. The specimens were tested for compressive strength using UTM compressive testing machine of 200KN capacities at a rate of loading of 140KN/min. The tests are carried out on triplicate specimens and an average compressive strength value wasrecorded.
The cube compressive strength (F_{ck}) was computed, from the fundamental principle as F_{ck} = Load at failure/cross sectional area (N/mm^2)

B) Flexural Strength Test

It is the resistance of concrete to tension under flexure loading. The tensile strength of concrete is primarily made to estimate the load under which cracking develops.

X. DETAILS OF TEST SAMPLES

A. *Number of Beams*

Totally 5 beams of size 150mm x150mm x750mm were cast and they are tested after 28 days fully immersed curing in water

B. *Reinforcement*

The bottom flexural reinforcement consists of two 10mm diameter bars and the top hanger bars consisted of two 8mm diameter bars. Stirrups made of 6mm diameter rods were used at a spacing of 100mm to provide adequate shear reinforcement. Here the beams were designed as under reinforced beams

C. *Casting of Specimen*

The specimens of size 750X 150x150mm were casted in the laboratory. Steel moulds were used for casting. Reinforcement cage was made and placed inside the moulds during casting. Required quantities of cement, sand, coarse aggregate, rice husk ash and nanosilica were weighed and mixed thoroughly by using mixing machine. Water was added later to the dry mix. Then the concrete was placed carefully in the moulds and the compaction was done using table vibrator. The specimens was de-moulded after 24hours and properly cured for 28 days.

D. *Test set up*

The casted specimens were tested for flexure under two point loading. The testing was done by using the test setup shown in fig.6. The size of the specimen is 750mmX150mmX150mm.

Fig.3. loading diagram for flexure strength

XI. TEST RESULTS AND DISCUSSION

TABLE III
TEST RESULTS FOR COMPRESSIVE STRENGTH

S.No	Specimen	CompStrength N/mm^2		Workability Slump (mm)
		7 days strength	28 days strength	
1	CC	21.92	29.71	92
2	20% RHA	19.29	27.72	90
3	20% RHA + 0.5% NS	22.44	35.15	90
4	20% RHA + 0.75% NS	23.48	36.78	91
5	20% RHA + 1% NS	24.56	42.26	93

TABLE IV
TEST RESULTS FOR FLEXURAL STRENGTH

S.No	Beam Specimen	Ultimate Load (KN)	Flexural Strength (N/mm^2)
1	CC	55.63	10.44
2	20% RHA	53.80	9.56
3	20% RHA + 0.5% NS	63.23	11.32
4	20% RHA + 0.75% NS	64.45	11.79
5	20% RHA + 1% NS	65.74	12.78

XII. CONCLUSIONS

Nanosilica and Rice husk ash incorporated concrete had showed higher strength compare to that of concrete without Nanosilica The workability of fresh concrete remains almost the same for normal as well as NS+ RHA concrete. Incorporating 1% NS into 20%RHA concrete caused an increase in compressive and flexure strength. It is found that disadvantages of rice husk ash had overcome by adding Nanosilica particles up to maximum limit of 1% with the average particle size of 10mm.

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