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Review of the Synthesis of Nano-Sized Ash from Local Waste for Use as Admixture or Filler in Engineering Soil Stabilization and Concrete Production

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Abstract

The synthesis of local nano-sized ash materials from local waste burnt and completely pulverized for use as admixtures or fillers in the stabilization or modification of weak engineering soil and the production of concrete is reviewed and the principles behind this all important aspect of nano technology X-rayed to give geotechnical engineers a clue and new turn in this area. These local waste materials as captured are palm bunch ash, coconut shell ash, palm kernel shell ash, bagasse ash, vehicle tyre ash, engine combustion ash, cigarette ash, fiber glass, pozzolan etc. Over the years, previous researches in the area of soil modification and stabilization of weak engineering soil have shown that remarkable improvement have been recorded in soil stabilization by using these ashes in their macro and micro scales. But in this era of nano technology and advent of nano-materials like nano copper, nano silica, nano carbon, nano aluminate, nano ferrite etc., resulting from chemical synthesis for various engineering uses, there is also the need to look into our readily available waste materials to nano-size the ashes making use of nano-sieves and nano filters and subjecting the collected powder to XRD test. These will lend to the research, parameters like wave length of X-ray (λ), full width of half maximum (β) and X-ray diffraction angle (θ). With these parameters, the average particle size of the powder under study would be determined using Debye-Scherrer's formula as shown in Equation 1and establish the important fact that the powder belongs to nano-sized particle ranging between 0.1 to 999 nm as either 0-D, 1-D, 2-D or 3-D nanomaterial. In the same vein, the nano-sized particles are used as fillers in the production of concrete which is subjected to strength characteristic tests to establish the improvements on concrete properties. With this approach, local waste materials ash is used at the nano-scale to affect engineering soil for use and improve the strength properties of both soil and concrete.

Keywords: *Admixture; Concrete Production; Filler; Nano-sized Ash; Soil Stabilization; Synthesis.*

1. INTRODUCTION

This is a general overview of the possibilities in terms of available literature of characterizing and synthesizing nanosized ash from local waste materials mainly in the developing world for use as admixture or fillers in the stabilization or modification of weak engineering soil and the production of concrete in the field of Materials and Geotechnical Engineering (Norazlan *et al.* 2015; Zaid *et al.* 2014). Nanosized ash in this context is any fine particle of average size within the range of 0.1 and 999 nm whose reactive surface area may have increased by 100% which took its nature and characterization from nano technology (Fan and Yongfeng, 2015). The idea of nanotechnology was first introduced in the 1959 by Richard Feynman in his lecture entitled "There's Plenty of Room at the Bottom" (Zaid and Mohd, 2013) a technology that made remarkable and swift progress years after. Technological improvements and advancements in this area of nanotechnology provided a state of the art approach to geotechnics which is being explored by this research. Common types of nanomaterials include nanotubes, dendrimers,

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quantum dots and fullerenes. Nanomaterials have applications in the field of nanotechnology and displays different physical and chemical characteristics from normal chemicals (i.e. silver nano, carbon nanotube, fullerene, photocatalyst, carbon nano, silica) (www.google.com, 2015). The National Nanotechnology Institute, NNI had defined "nanotechnology" as the control, comprehension and reformation of material based on the hierarchy of nanometers to develop matter with essentially new uses and a new constitution (Zaid and Mohd, 2013; Mansoori *et al.* 2008; Juh, 2007; Li-Ming *et al.* 2011). Considering this definition, nanotechnology is a novel approach in all sciences. Such an approach can be applied in geotechnical engineering in two ways:

(i) in studying the soil structure in nanometer scale to gain a better understanding of soil nature, as well as in studying the performance of soils with different nanostructures
(ii) in conducting soil manipulation at the atomic or molecular scale, which is facilitated by the addition of nanoparticles as an external factor to soil. It is important to note at this point that nanomaterials are classified into the following geometric groups thus

(i) 0-D: with all the dimensions at the nanoscale
(ii) 1-D: with two dimensions at the nanoscale and one dimension at the macro scale
(iii) 2-D: with one dimension at the nanoscale and two dimensions at the macroscale and
(iv) 3-D: with no dimension at the nanoscale and all dimensions at the macroscale.

The second approach as recorded above is particularly the basis and aim of this research work to harness the available waste materials ash which in the past years researchers have used in their macro and micro scale to improve the geotechnical properties of engineering soil (Nirmala and Singaravadivelan, 2014). There have been nano-silica, nano-ferrite, nano-copper, nano-zinc, nano-sulphite, nano-carbonate, nano-aluminate, nano-titanium, nano-silver, nano-gold, carbon black (Masaki and Eiji, 2006), nano-clay, nano-ceramics (Reenu *et al.* 2015) etc that have been used and these nano particles have considerably at differently degrees improved the construction properties of engineering soil and saved a lot of cost in engineering projects (Mansoori *et al.* 2008; Ershadi *et al.* 2011; Fan and Yongfeng, 2015; Bao *et al.* 2011).

2. MATERIALS & METHOD

Waste materials e.g. palm bunch, baggasse, waste paper, exhaust ash, cigarette ash, coconut shell, palm kernel shell, dry animal bone, quarry dust, vehicle tyre etc are collected, sun dried, burnt and completely pulverized to nanosize the ash by passing the collected powder through nano filters or sieves with sizes 10 nm, 20 nm, 50 nm, 100 nm, 200 nm, 500 nm and 800nm (Anitha and Haresh, 2014). The above nanosized ash is subjected to characterization by X-ray Diffraction Test to determine the following parameters; wave length of x-ray (λ), full width of half maximum (β) and X-ray diffraction angle (θ) (Satish *et al.* 2015). The above technique is approached in various forms and procedures giving varying degrees of accuracy and precision thus High-Resolution Transmission Electron Microscope (HRTEM), Photon Correlation Spectroscopy (PCS) which uses a Malvern Zetasizer Nano ZS laser particle, Dynamic Light Scattering (DLS), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Small Angle X-ray Scattering (SAXS), Scanning Mobility Particle Sizer (SMPS), Energy Dispersive Spectroscopy (EDS), Selected Area Electron Diffraction (SAED), Atomic Force Microscopy (AFM), Convergent Beam Electron Diffraction (CBED) etc. The Debye-Scherrer's formula is thereafter applied to determine the average particle size (D) of the ash under study which many researchers have applied previously though on the synthesis of the known nanomaterials as listed above as follows; (Thomas, 2005; Daniele, 2013; Ashley, 2011; ESN, 2008; Neale *et al.* 2009; Laila *et al.* 2010; Ahmad *et al.* 2013; Justyna, 2013; Zaid and Mohd, 2011; Asama *et al.* 2013; Xiao *et al.* 2005; Chang-jun *et al.* 2010; Chien-I *et al.* 2008; Hall *et al.* 2000; Sovan *et al.* 2011; Fan and Yongfeng, 2015; Bao *et al.* 2011; Kalpana *et al.* 2009; Kannan, 2010; Tay *et al.* 2012; Anamika *et al.* 2011; Vorgelegt, 2013; Kavitha *et al.* 2015; Akbari *et al.* 2011; Jennifer, 2007; Kikuo and Wuled, 2004; Li-Ming *et al.* 2011).

$$D = \frac{0.9\lambda}{\beta cos\theta} \quad (1)$$

β is obtained from the corrected FWHM by convoluting Gaussian profile which models the specimen broadening β_r as follows; (Bao *et al.* 2011; Kalpana *et al.* 2009; Kannan, 2010; Tay *et al.* 2012; Anamika *et al.* 2011; Vorgelegt, 2013; Kavitha *et al.* 2015; Akbari *et al.* 2011; Jennifer, 2007; Kikuo and Wuled, 2004; Li-Ming *et al.* 2011) ;

$$\beta_r^2 = \beta_0^2 - \beta_i^2 \quad (2)$$

Where β_0 is observed broadening and β_i is instrumental broadening.

3. EXPECTED RESULTS

Over the years, geotechnical engineering has recorded remarkable improvement in the geotechnical properties of engineering soil through the application and use of ash from different classes of waste materials as admixtures in the stabilization of the engineering soil for sub-grade and road base construction and general stabilization of engineering soils for different geotechnical engineering purposes. The above has been at the macro and micro scales (Mohammed, 2007; Osinubi, 2009; Ahawike and Stephen, 2009; Ekpo and Ihedioha, 2010; Agbo and Eze-Uzoamaka, 2010). The present work has reviewed the synthesis of local nanosized ash from the already known substances in use and the application of same as admixture and fillers. Brunauer-Emmett-Teller, BET Surface Area Analysis and Peak Broadening Analysis have shown in previous researches that the foregoing procedure increases the reactive surface area of the ash with cementing materials and the soil under investigation thereby yielding modified soil with considerably higher and improved geotechnical properties (Rafat and Mohammad, 2011). Previous researches have also shown that many local waste materials at the macro and micro scales have been used as fillers to produce light weight concrete and recorded remarkable improvements in the concrete engineering and construction properties which include consistency, workability, slump, compressive strength etc at different curing time periods (Osadebe *et al.* 2007). However the use of nanomaterials as fillers have been in use and the records are there of the considerable improvement this has shown in the production of concrete (Behfarnia and Keivan, 2013; Laila *et al.* 2010; Konstantin *et al.* 2006; Farag *et al.* 2014; Ali *et al.* 2011; Hesam *et al.* 2013; Maheswaran *et al.* 2013). With the above improvements, it is hopeful that the increase in surface area of these ash materials at the nanoscale will improve the reaction index between the admixture/filler, cement/binder and other aggregate materials for the production of improved concrete.

4. CONCLUSION

With the foregoing it is obvious that the synthesis of nanosized ash from local waste materials for use as admixture and filler in the stabilization of weak engineering soil and concrete production respectively will make a remarkable breakthrough in the field of geotechnical engineering by considerably and alternately improving the strength properties of engineering soil and concrete and at the same time place nanotechnology on another recognizable platform by adding to its numerous records in different fields of science and technology.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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