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Prediction of Size and Elemental Compositions of Groundnut Shell Ash and GGBS using SEM and EDX Analysis

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ABSTRACT

Large volume of Groundnut shell and Ground Granulated Blast Furnace Slag (GGBS) are disposed directly from the industries on the land without doing any further treatment. These discharged waste materials are making nuisance to the environment, when it was discarded over the earth surface and thus making the environmental issues and illness to the peoples. Therefore, it is planned to investigate the possibilities to use the Groundnut shell and Ground Granulated Blast Furnace Slag GGBS in the form of ash for the production of concrete in the construction industries for the replacement of cement. In this works, it is planned to perform the SEM and EDX analysis to predict the elemental components and size of Groundnut Shell Ash (GSA) and GGBS.

By analyzing the results obtained by conducting the SEM and EDX analysis, it was examined that the size of the GSA and GGBS are less than 75m and 45μm respectively. The GSA and GGBS contains large amount of oxides of calcium, magnesium, potassium, silica and aluminium. The components and their proportions of the minerals of the GSA and GGBS are very match with the cement. Hence, it is suggested that the GSA and GGBS could be replaced for the partial replacement of cement for making concrete. Also, the size of the GSA and GGBS are less than the size of the cement particles and hence it will help to enhance the strength and durability properties of concrete matrix.

KEYWORDS: *Groundnut Shell Ash, Ground Granulated Blast Furnace Slag, SEM, EDX*

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1. INTRODUCTION

Recently, the cement plays a important role for making concrete in the construction fields. Hence, the requirement of cement is significant in the construction of civil engineering structures, like, industries, Infrastructure, bridges, water retaining dam, retaining walls, and pavement of road. Therefore, the manufacturing of cement is increased in the cement industry to meet up such a demand in the construction fields.

Carbon di-oxide (CO_2) is released from cement industries during the dry process of cement manufacturing due to combustion of fuels in the kiln and power generation. It contributes about more than 5% of global anthropogenic CO_2 emission [1]. Approximately, 1.25tonnes of CO_2 is released per tonne of cement production in the industries [2]. Cement industries are one of the highest CO_2 producers when compared to other industries [3]. The emission of CO_2 progressed to environmental issues and it also increase the global temperature to cause global warming [4]. On the other hand, the poor people are facing lot of problems to construct their own houses in their locality due to the constantly increasing the cost of cement [5-6]. These two major problems, such as Global warming and constant raising the cost of cement have encouraged many researchers to look the most suitable alternative supplementary cementing materials for the substitution of cement. By considering these problems, our present research work was carried out to identify the successful way for the partial replacement of cement with waste materials discharged from both agricultural and industries.

Now-a-days, huge volume of agricultural and industrial waste materials such as, groundnut shell, comb cob, saw dust, rice husk, coconut shell, ground granulated blast-furnace slag, fly ash, silica fume, metakaolin, etc., are directly discharged on the land without any treatment. It creates serious environmental issues. A small quantity of these waste materials was properly used but most of them were not utilized. These disposed waste materials also create disease to the people and animals. The ash obtained from various agricultural and industrial by–product waste materials has a good pozzolanic property and therefore, it could be used as a pozzolanic material for the partial replacement of cement. The replacement of cement with ash obtained from waste materials plays a important role for the preparation of concrete and it reduces the permeability by altering the pore structure of concrete, and thus enhancing the durability performance of concrete against deterioration and penetration [7]. Further, the concrete manufacturing with addition of agricultural and industrial waste ash increases the mechanical properties of concrete by altering the micro structure of concrete. Therefore, it is planned to predict the mineral components and their sizes of GSA, GGBS and Cement (OPC) using the SEM and EDX analysis.

2. CHARACTERISTICS OF SEM AND EDX
The size and shape of the GSA, GGBS and cement used in the research work were examined using Scanning Electron Microscopy (SEM) analyses and the elemental composition of GSA, GGBS and cement were obtained by Energy Dispersive X-ray (EDX) analysis.

2.1. Experimental set up of SEM:
Scanning Electron Microscopy (SEM) analysis was carried out by a JEOL JSM- 6360 electron microscope. For SEM imaging to envisage the size and shape of the GSA, GGBS and Cement samples was kept over the carbon strip attached to a SEM brass, extra ash and cement was removed using blotting paper and then allowed to dry by putting it under a mercury lamp for 5 min.

2.2. Experimental set up of EDX
The elemental compositions of GSA, GGBS and Cement were obtained by using Energy Dispersive X-ray (EDX) analysis (JEOL JSM-6360) at changeable pressure scanning electron microscope attached with INCA X-sight Oxford instrument facility, at an acceleration voltage of 20 keV.

3. SEM AND EDX ANALYSIS:
3.1. SEM and EDX analysis of GSA
The overall morphological shapes of the GSA are unspecified structural shapes observed in the lower magnification, and further majorly spherical shape at higher magnification. The average sizes of the particles were 10-75µm. Fig. 1 has shown the SEM image of GSA. The elemental analysis of GSA is shown in Fig. 2. This shows a strong signal of elemental Ca and other signals of elements like K, Al, Mg, Si and O. The EDX spectra displayed an optical absorption band peaking at 2.15keV. Further, EDX analyses suggested many elements were present in the GSA and they were strongly responsible for the stability of the concrete. Table 1 shows the elemental components of the GSA sample.

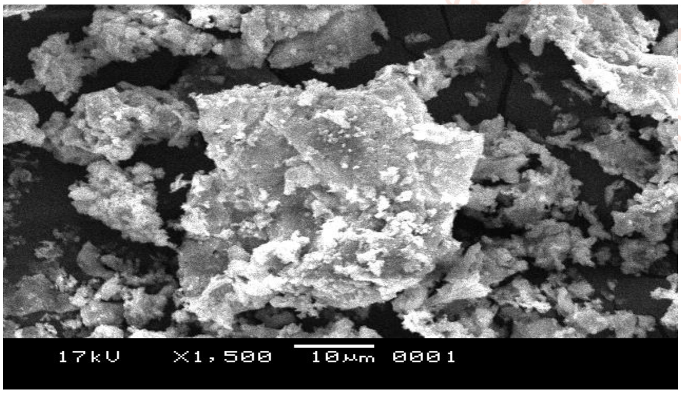

Fig. 1: SEM image of GSA sample

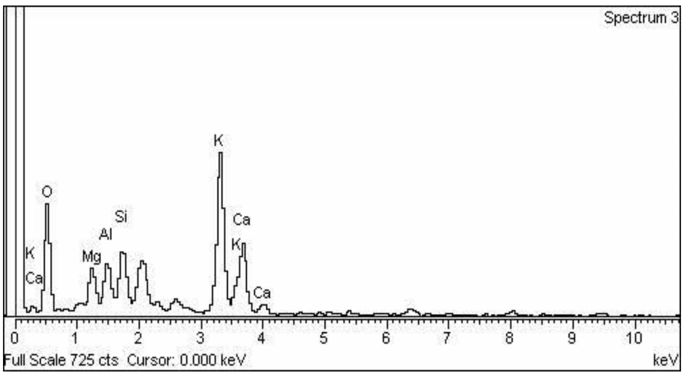

Fig. 2: EDX analysis of GSA sample

Table 1: Elemental components of GSA

Sl. No.	Element	Weight (%)
1	Silicon Oxide (SiO_2)	27.46
2	Calcium Oxide (CaO)	16.57
3	Aluminium Oxide (Al_2O_3)	7.74
4	Magnesium Oxide (MgO)	5.19
5	Potassium Oxide (K_2O)	23.69
6	Others in the form of oxide	11.87
7	Loss of ignition	7.48
Total		100.00

3.2. SEM and EDX analysis of GGBS
The SEM image of GGBS is shown in Fig. 3. The major morphological shapes of the GGBS are rectangular at higher magnification. The average sizes of the particles were 10-45µm.

EDX analysis of GGBS as in Fig. 4 shows a strong signal for elemental Ca other signals of elements (Si, Al, Mg, K and O). The GGBS crystallites display an optical absorption band peaking at 2.15keV. EDX analysis suggested that many chemicals were absorbed on the surface of the GGBS and are strongly responsible for the stability of the synthesized GGBS. Table 2 shows the elemental components of the GGBS sample.

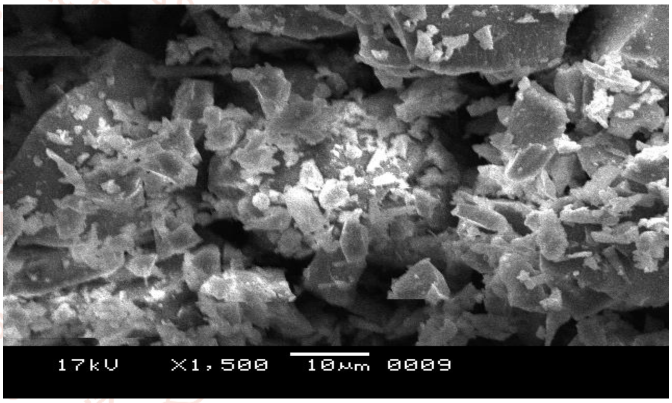

Fig. 3: SEM image of GGBS Sample

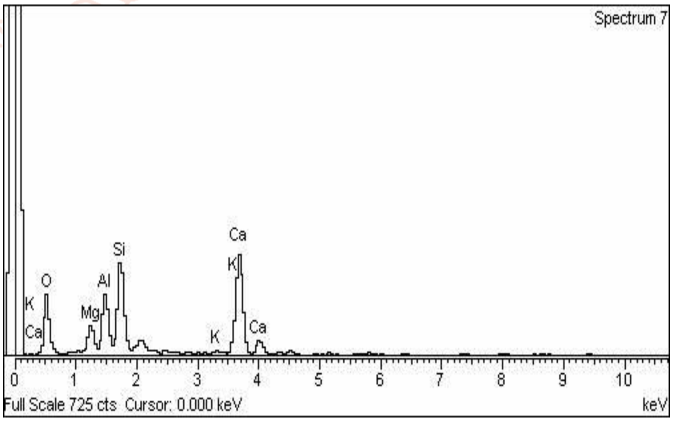

Fig. 4: EDX analysis of GGBS sample

Table 2: Elemental components of GGBS

Sl. No.	Element	Weight (%)
1	Silicon Oxide (SiO_2)	37.74
2	Calcium Oxide (CaO)	39.53
3	Aluminium Oxide (Al_2O_3)	13.18
4	Magnesium Oxide (MgO)	8.16
5	Potassium Oxide (K_2O)	0.52
6	Loss of ignition	0.87
Total		100.00

3.3. SEM and EDX Analysis of Cement

The overall morphological shape of the cement is spherical at higher magnification. The average sizes of the particles were 10-90µm. The SEM image of the cement is shown in Fig. 5. EDX analysis of cement has shown in Fig. 6, displays a strong signal for elemental Ca other signals of elements (Si, Na, Al, S, K, Fe and Sb). The cement crystallites display an optical absorption band peaking at 2.15keV. EDX analysis suggested that many chemicals were absorbed on the surface of the cement and are strongly responsible for the stability of the synthesized cement. Table 3 shows the elemental components of the cement sample.

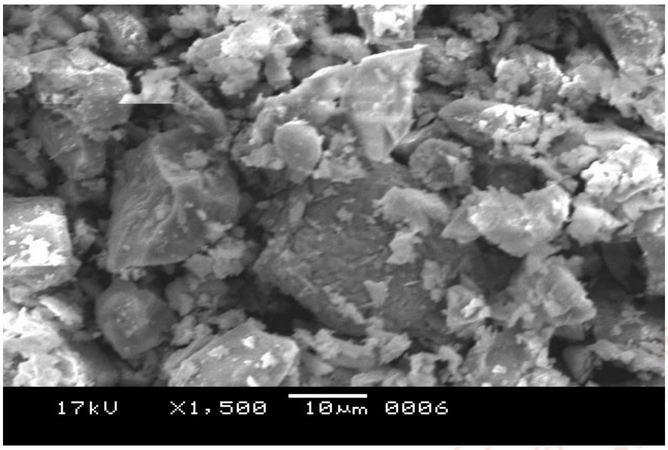

Fig. 5: SEM image of cement Sample

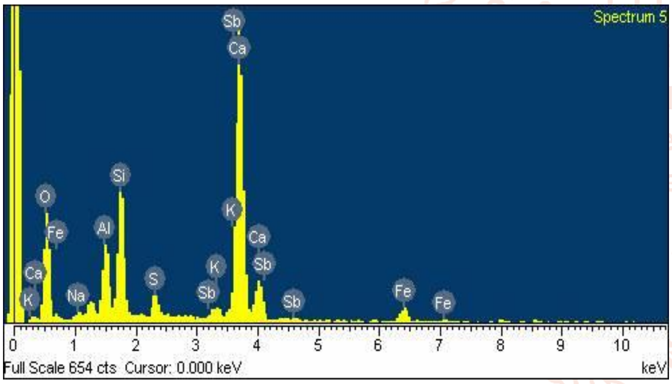

Fig. 6: EDX analysis of cement sample

Table 3: Elemental components of cement

Sl. No.	Element	Weight (%)
1	Silicon Oxide (SiO_2)	23.62
2	Calcium Oxide (CaO)	60.28
3	Aluminium Oxide (Al_2O_3)	5.26
4	Magnesium Oxide (MgO)	3.87
5	Potassium Oxide (K_2O)	0.89
6	Sodium Oxide (Na_2O)	1.08
7	Ferric Oxide (Fe_2O_3)	0.47
8	Sulphur (S)	0.97
9	Others in the form of oxide	1.25
10	Loss of ignition	2.31
Total		100.00

4. RESULTS AND DISCUSSIONS:

The following discussions were established after examined the elemental analysis of GSA, GGBS and cement using SEM and EDX.

1. By performing SEM analyse, it was observed that the size of the Groundnut Shell Ash (GSA) and Ground Granulated Blast Furnace (GGBS) are varying from 10µm - 75µm and 10µm - 45µm respectively, where as the size of cement particle is varying from 10µm - 90µm. From this SEM analysis, it was observed that the size of the GSA and GGBS are very finer than the mineral particle of cement particle. The smaller size particle of GSA and GGBS helps to enhance the durability properties as well as strength characteristics of concrete matrix.
2. From EDX analyse, it was observed that the GSA and GGBS contains strong signal for elemental compositions of oxides of calcium, magnesium, potassium, silica and aluminium. The table 3 shows that majority of the elemental proportions which contains in the GSA and GGBS were very close to the cement sample (OPC). Hence, these waste materials could be used as pozzolanic materials for the replacement of cement content.

Table 3: Comparison of Mineral components of the WPS ash and Cement Sample

Sl. No.	Mineral Elements	GSA	GGBS	Cement (OPC)
		Weight (%)		
1	Silicon Oxide (SiO_2)	27.46	37.74	23.62
2	Calcium Oxide (CaO)	16.57	39.53	60.28
3	Aluminium Oxide (Al_2O_3)	7.74	13.18	5.26
4	Magnesium Oxide (MgO)	5.19	8.16	3.87
5	Potassium Oxide (K_2O)	23.69	0.52	0.89
6	Sodium Oxide (Na_2O)	-	-	1.08
7	Ferric Oxide (Fe_2O_3)	-	-	0.47
8	Sulphur (S)	-	-	0.97
9	Others in the form of oxide	11.87	-	1.25
10	Loss of ignition	7.48	0.87	2.31
Total		100.00	100.00	100.00

5. CONCLUSION:

1. The size of the mineral admixtures available in the GSA and GGBS sample is very finer than the size of the mineral particles of the Cement and hence it is observed that the finer particles of the GSA and GGBS degrease the pores of the concrete matrix and thus increasing the durability performance and strength characteristics of concrete.
2. The GSA and GGBS contains large amount oxides of calcium, magnesium, potassium, silica and aluminium. It is maintaining the strength carrying capacity of the concrete containing GSA and GGBS. Hence, the GSA and GGBS materials could be utilized as pozzolanic materials for replacing the cement for the production of concrete.

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