RESEARCH ARTICLE

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Study on the Performance of Natural Fibres Reinforced Alkali Activated Composites

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Abstract

The key component in concrete production is cement. However, its production generates substantial quantity of greenhouse gas. Alkali activated composites(AAC) are alumino silicate polymers which has been gaining much attention in recent years as it strives towards replacing cement as a binder. Binders as such produced using cement or AAC are very strong in compression, however, they have low tensile and flexural strength. Incorporating steel fibres has been an age old method to improve the tensile strength. This paper focuses on the use of natural fibres as a substitute of micro steel in AAC. Two natural fibres namely pineapple and banana fibre has been studied for mechanical strength and durability properties in AAC production. The experimental work also include a brief study on the surface structure of the materials used using Scanning Electron Microscope (SEM) followed by Energy Dispersive X-ray (EDX) analysis.

Keywords: Banana fibre, compressive strength, pineapple fibre, tensile strength.

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Introduction

Growth in infrastructure relies extensively on construction materials and Ordinary Portland Cement (OPC) is considered as one of the most important material. The production of cement is increasing by about 3% annually[1]. The production of one ton of cement liberates about one ton of CO_2 to the atmosphere, as a result of de-carbonation of limestone in the kiln and the combustion of fossil fuels[2]. Such environmental impact calls for the need of an alternate sustainable source of material which possess binding property as those of cement[3].

It was the proposal of Joseph Davidovits that a liquid of alkaline nature could be made to react with a source material whose origin may be geological or a by-product material which should necessarily contain aluminum (Al) and silicon (Si). The reaction that follows is the process of polymerization and the end result produces binders. Thus, Davidovits (1994, 1999) referred the binders by the term 'Geopolymer'. Geopolymers are members of the family of inorganic polymers [4, 5].

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When the source material has higher content of calcium oxide as in the case of Ground Granulated Blast Furnace Slag (GGBS), the term Alkali Activated Composites is also used[6,7]. Alike cement, AAC performs better in terms of compressive strength rather than the tensile strength. The use of fibres in geopolymers helps in making it ductile or quasi ductile, thus aiding to its overall tensile strength [8-10]. The aim of this experimental study is to develop AAC based on GGBS and further reinforced those specimens using two types of natural fibres. The fibres in used are pineapple and banana fibres. Finally, the fibre reinforced AAC samples shall be compared to the properties of their AAC counterparts.

Experimental Program

The materials used for the present experimental investigation is GGBS. For activating solution, Sodium hydroxide pellets and Sodium silicate are used. Two types of natural fibres i.e. pineapple fibre of diameter 32.06 µm and banana fibre of diameter 64.08 µm shall be used as reinforcement at different percentages. The SEM images of GGBS, pineapple and banana fibres in their raw state are shown in figure 1 and their corresponding EDX are shown in figure 2.

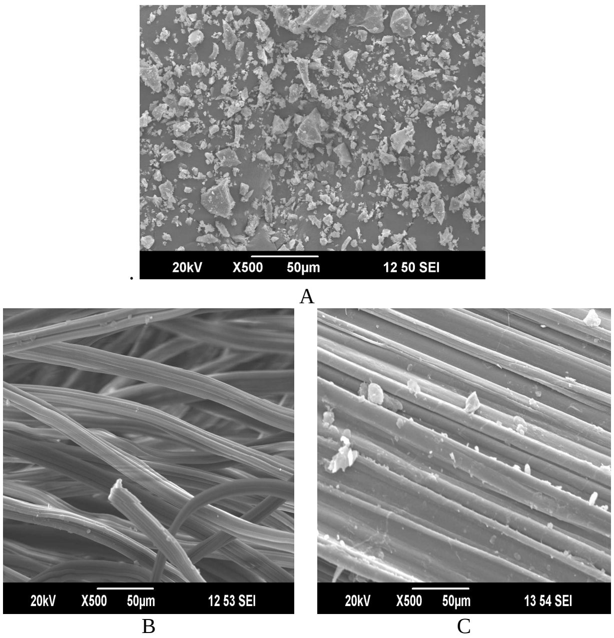
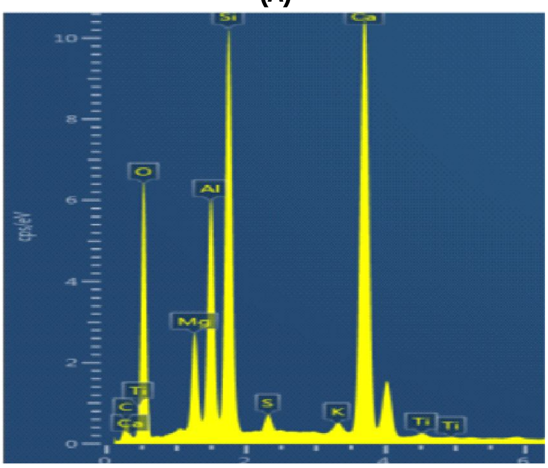


Figure 1: SEM images of GGBS (A), pineapple fibre (B), banana fibre (C)

(A)



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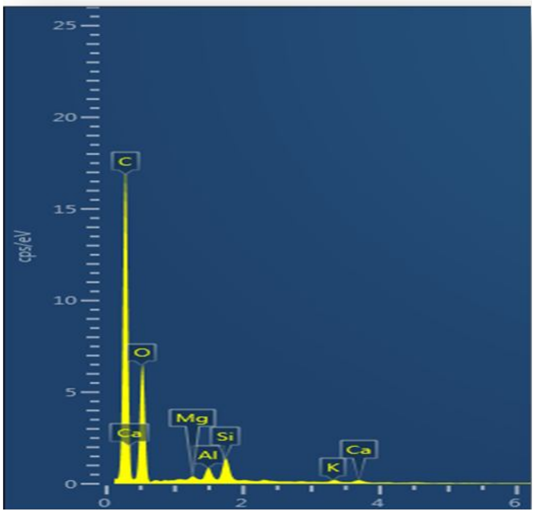

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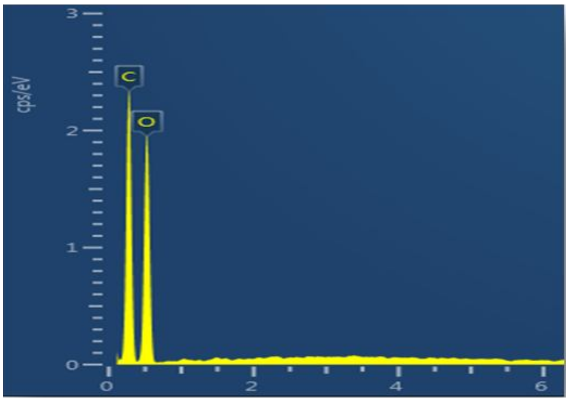

Figure 2: EDX images of GGBS (A), pineapple fibre (B), banana fibre (C).

In the EDX measurement, focused was made on different areas and the corresponding peaks are shown in Figure 2 A-C. It was taken to detect the chemical composition of the materials used in the experimental study. The details of the three EDX spectra values measured in atomic and weight percent for GGBS are listed in table-1 and EDX of pineapple and banana fibre are listed in table-2.

Table-1: EDX Results of GGBS

Element	Weight %	Atomic %
C	7.37	12.66
O	43.43	56.0
Mg	3.51	2.98
Al	7.59	5.8
Si	13.09	9.62
S	0.71	0.46
K	0.42	0.22
Ca	23.54	12.11
Ti	0.33	0.14

Table-2: EDX results of pineapple and banana fibre

	Pineapple fibre		Banana fibre	
Element	Weight %	Atomic %	Weight %	Atomic %
C	63.02	70.0	47.09	54.24
O	34.72	28.95	52.91	45.76
Mg	0.21	0.11	-	-
Al	0.65	0.32	-	-
Si	1.04	0.5	-	-
K	0.17	0.06	-	-
Ca	0.19	0.06	-	-

SPECIMEN PREPARATION

The alkaline activating solution used in the manufacture of alkali activated composites (AAC) was a mixture of sodium hydroxide solids, sodium silicate solution and water. The weight of both sodium hydroxide and sodium silicate was fixed at 8 percent of GGBS. The Composition of sodium hydroxide used for the study consists of 77.5% of sodium oxide and 22.5% of water and the composition of sodium silicate consists of 14.15% of sodium oxide, 30.65% of silicon dioxide and 55.2% of water. The molarity obtained for the activating solution is 8 Molar. The water to binder ratio was kept at 0.33.

Two types of fibres namely pineapple and banana were reinforced in two different percentages i.e. 0.25% and 0.50%. The details of the test specimen are given in table III. The specimens were mixed in a non-absorbent container and later transferred into steel cube moulds of 50x50x50 mm and cylindrical mould of 50 mm diameter and 100 mm length.

The specimens were cured dry at ambient temperature until tested. Images of some demoulded specimens are presented in Figure 3 and Figure 4.

Figure 3: Demoulded Cube Specimens

Figure 4: Demoulded Cylinder Specimens

Table-3: Details of Test Specimen

Specimen ID	GB	GPN1	GPN2	GBN1	GBN2
GGBS %	100	100	100	100	100
Water/binder ratio	0.33	0.33	0.33	0.33	0.33
Pineapple fibre %	-	0.25	0.50	-	-
Banana fibre %	-	-	-	0.25	0.50

TEST CONDUCTED

The tests conducted on the specimens was for durability and strength. Water absorption and apparent porosity test was conducted for durability studies. Cube specimens were checked for the compressive strength and tensile strength was tested on cylindrical specimens.

RESULTS AND DISCUSSIONS

Water Absorption and Apparent Porosity

Water absorption and apparent porosity are simple yet effective method to study the durability properties of binders. The graph for water absorption and apparent porosity is shown in Figure 5. GPN2 samples exhibited lowest percentage of water absorption and apparent porosity followed by sample GPN1. In both the case of fibres, increasing the percentage of fibres decreases water absorption and apparent porosity. This observation may be explained by the fact that the fibres checked the capillary movement of water by blocking the voids present in the specimens.

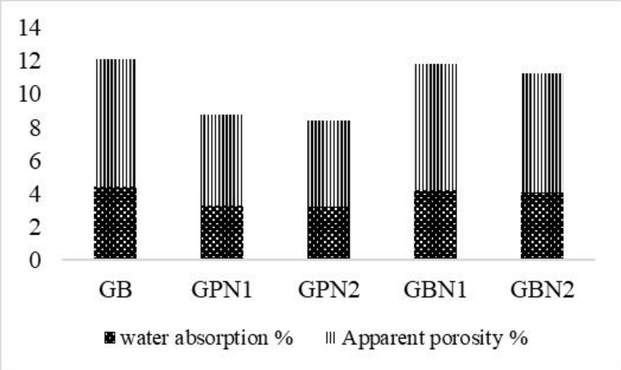

Figure 5: Water Absorption and Apparent Porosity of the Samples

Compressive Strength

The compressive strength of the specimens are shown in Figure 6. In case of compressive strength, intensification in fibre percentage leads to improvement in compressive strength. All the fibre reinforced specimens yielded higher compressive strength than sample GB.

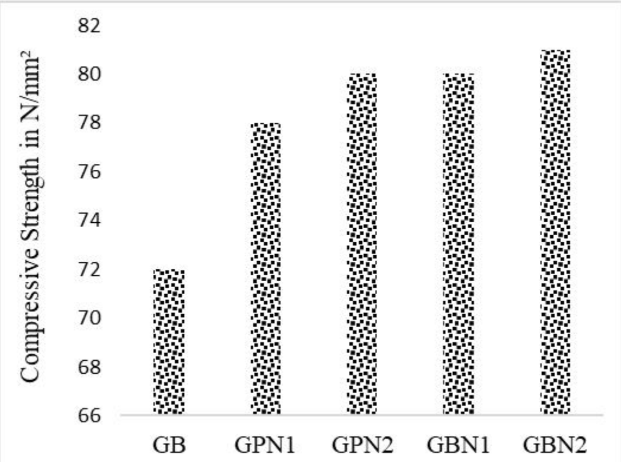

Figure 6: Compressive Strength of the Samples

Tensile Strength

The cylindrical specimens were tested for their tensile strength. In the case of compressive strength, GBN2 specimen exhibited the highest value. However, in the case of tensile strength, GPN2 samples gave the highest tensile strength value followed by GPN1. The tensile strength of the specimens are shown in Figure 7.

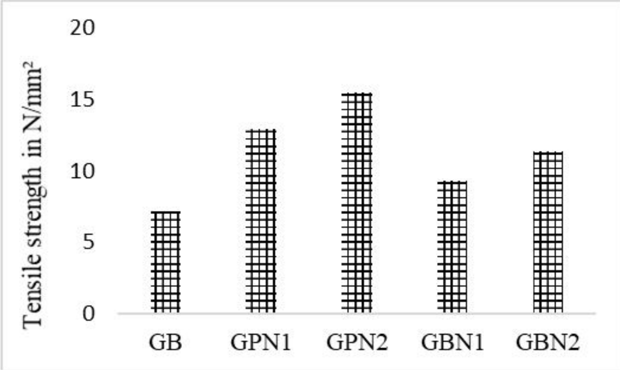

Figure 7: Tensile Strength of the Samples

Conclusion

Based on the limited study on the durability and strength of the natural fibre reinforced AAC, the following points are drawn as the conclusion:

1) The SEM analysis on raw GGBS powder shows an amorphous microstructure and the micrographs shows Calcium and Oxygen as the major constituent followed by Silicon. However, no significant traces of elemental constituents other than Oxygen and Carbon were detected in banana fibre.
2) The durability properties of AAC were improved with the reinforcement of pineapple fibre.
3) In both the case of fibres, the compressive strength was found to be directly proportional to fibre percentage. However, banana fibre reinforcement gave higher compressive strength values.
4) In the case of tensile strength, use of pineapple fibre as an reinforcement yielded the highest tensile strength.
5) The test results suggested that addition of natural fibres mainly aids in improving the strength of the specimens.
6) Natural fibres could also prove to be economical when compared to the most commonly used reinforcing materials such as steel fibres especially when the region falls in places where mineral resources are low.

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