ADVANCED GEOPOLYMER COMPOSITES FOR STRUCTURAL AND BIOMEDICAL APPLICATIONS

New York City College Of Technology, CUNY
Department of Mechanical Engineering Technology *(Composite and Biomaterial Lab)*
Student: Tin Oo and Raul Idris Rosario
Mentor: Dr. Akm Rahman

ABSTRACT

The current research focused on the development of Geopolymer based fiber reinforced composites for thermal and structural applications. This study involved Fly Ash(FA) based geopolymer formulations as the matrix of woven Glass fiber reinforcements (FAGP) at 0.40 to 0.60 volume fractions. Several Nano and microscale materials such as Rice Husk Ash (RHA), Zirconia, Silicon carbide whisker were added in the geopolymer matrix. The effect of processing temperatures were evaluated The results suggest that , compression strength of neat FA geopolymer increased by 7% and 14% with the addition of Zirconia and RHA. Also it is found that, post treatment at 150 °C resulted in decrease in flexural strengths of FAGP by a small margin, while the Flexural modulus improved by almost 76%. The potential application of this geopolymer formulations would be structural members including reinforced concrete, partition board and environmental barrier particularly in under ground tunnel.

INTRODUCTION

A global interest has grown immensely that people seek new ways of creating for industrial, health, and commercial that are more in tune with the natural world instead of disruptive to its rhythms. Recently several published papers supports the evidence of Geopolymer formulations with high thermal stability, for potential application to composite industry Green ceramics is an alternative materials which can be processed at low temperature using environment friendly materials including Rice husk ash, glass fibers, and a Fly Ash Geopolymer. Optimum formulation of the compositions and processing condition are the critical criterion of the optimum properties of Geopolymer. As a primary, this project focuses on the development of a Fly Ash based Geopolymer that is process-able at a low temperature but is applicable to high temperature environments, resulting in a lower energy costing material, and to understand the role of the material components used and varying mole ratios in the inherent strengthening mechanism of this blinder, and its use as the matrix of the fiber reinforced composite to create a compatible interface between the fiber and Geopolymer. The formulation of this binder is to be developed using fly ash in an alkali silicate medium.

SUMMARY

At first Geopolymer was formulated using careful selection of Fly Ash , KOH and silicate compositions. Then woven glass fabric was applied in the geopolymer. Several micro and nanofillers were added to evaluate interfacial bonding. Scanning Electron microscopy suggested that those fillers bonded well with geopolymer and resulted in improved compressive and flexural strengths. Ultimate goal of this research is to utilize Geopolymer composite into the replacement of ordinary cement based structural composite. Further analysis is required to clearly understand the strength and structure-property relationship of Geopolymer.

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METHOD-1(PROCESSING OF GEOPOLYMER)

Geopolymer was formulated with few compositions of Class F Fly Ash, KOH and K_2SiO_3. Then RHA and ZrO2 were separately added to reinforce the Geopolymer. Fig.1 shows the steps for RHA processing.


(a) Rice Hush after washing with water


(b) Rice Hush Ash after 1400F for 5 hours

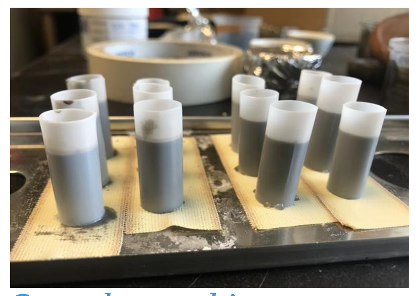

(c) Curshed Rice Hush Ask

Fig(1): Processing of Rice Hush Ash (RHA)

Precursor	Neat	FAGP-1	FAGP-2
	Wt%	Wt%	Wt%
FA-Class F	33%	32%	32%
K2SiO3	42%	41%	41%
H2O	18%	18%	18%
KOH	6%	5%	5%
RHA	-	3%	-
ZrO2	-	-	3%

Table (1): Compositions of Geopolymer precursors

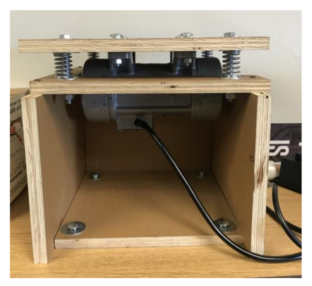
The resultant mixture were made according to Table.1 and degassed inside of a desiccator under 15 mm Hg vacuum. The mixture was then poured into the mold in order to make specimens for compression and flexural tests.



Fig(2): Process of Geopolymer Samples making
(a) Mixture degassing in desiccator
(b) Compressive test specimen in the mold Fly Ash Geopolymer Neat samples (left) FAGP-1 and FAGP-2(right)

Several characterization techniques were involved in this study. In addition to custom creating laboratory equipment *(Fig.3)* that allow for consistent specimen creation. we assigned common testing procedures for materials; Compression, Thermal Resistance, Microscopy, and Flexural testing. The fire resistance study showed some pitting formation in the range of 80 to 500 °C which suggests removal of entrapped air bubbles. 100°C and above samples were wrapped in Aluminum foil to prevent from expending.

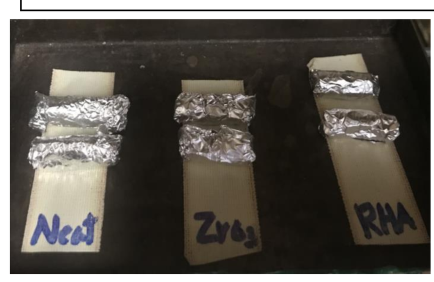
Fig(3) Custom Made Laboratory Equipment.

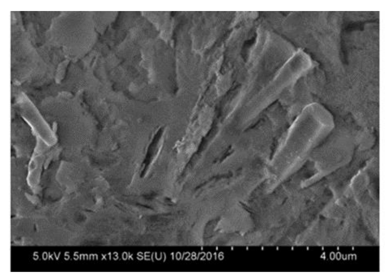

(a)Shaking table


(b)The inner workshopped Piece panel mold

Table 2: Cure and Post processing schedule

Cure and Post Processing scheme	Meaning
RT	Cured at Room Temperature 24 hr
80 °C	Cured at 80 °C 24 hr and dried at 100 °C 5 hr
150 °C	Cured at 80 °C 24 hr, dried at 100 °C (5hr) and 150 °C (5hr)
250 °C	Cured at 80 °C 24 hr, dried at 100 °C (5hr) and 350 °C(5hr)

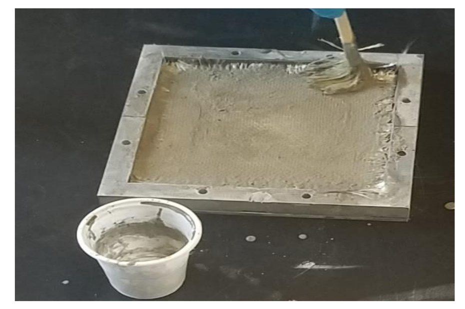




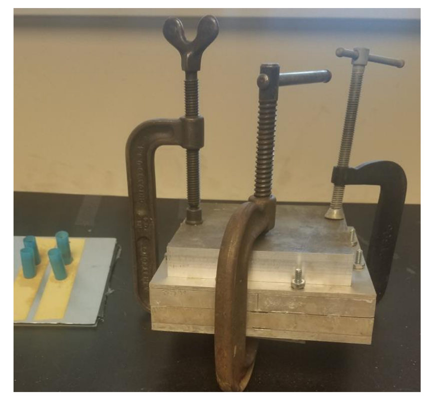
Fig(4) Post processing and Testing
(a)FAGP samples wrapped in Aluminum foil for 150C post heating
(b) Polished samples of FAGP-1 and FAGP-2
(c) Compression test setup in the compression fixture of Instron C 1101.
(d)Microscopy images of Geopolymer

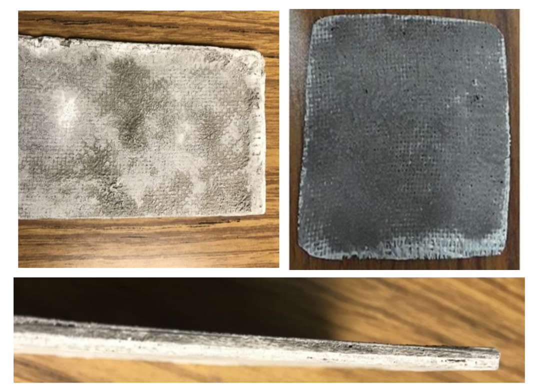
METHOD-2. (PROCESSING OF GEOPOLYMER PANEL)

After Perfecting Fly Ash based Geopolymer, Then use as the matrix of the fiber reinforced composites to create a compatible interface between the fiber and Geopolymer. Since fiber glass is one of the least expensive reinforcements, a compatible interface coating could be a viable solution to green composite which may be applicable to partition board.
Fig.5 shows the steps for processing Geopolymer panel.



Fig(5) process of Geopolymer panel.
(a) Orignal Glass fiber (left) Heat treating fiber glass at 650 °C for 30 min (right)
(b) Layering glass fiber and Geopolymer mixture in the plate
(c) Closing the panel with screws


(d) Applying pressure and loads Then leave in oven at 80°C for overnight.

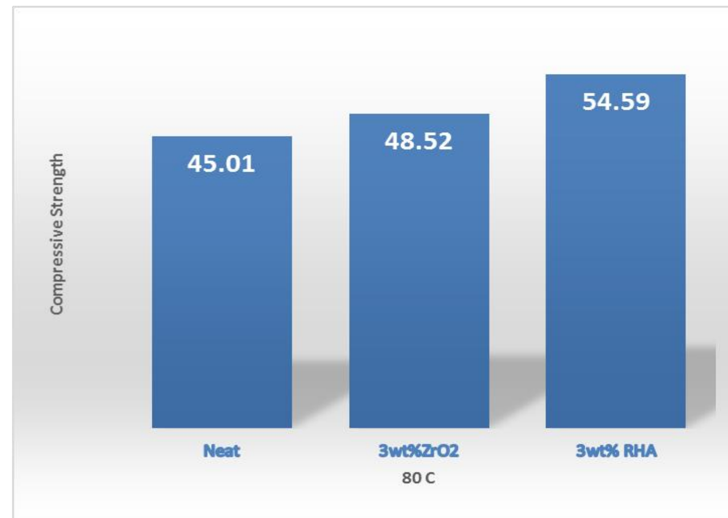

(e)Panels of 8 to 10 layers with a thickness of 3 to 4 mm.


(f) Fiber reinforced composite strip for Flexural test

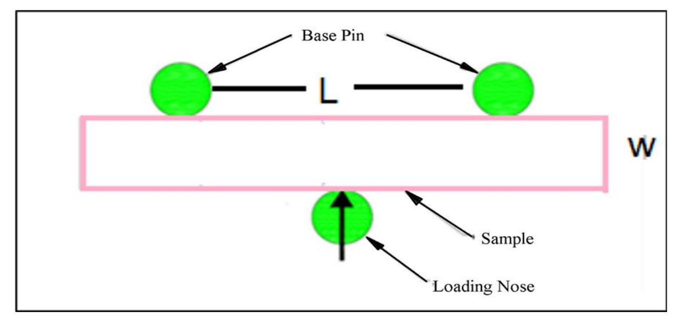
RESULTS

RHA/ZrO2 ratio between two to four is optimum for improvement in compressive strength and flexure strength.

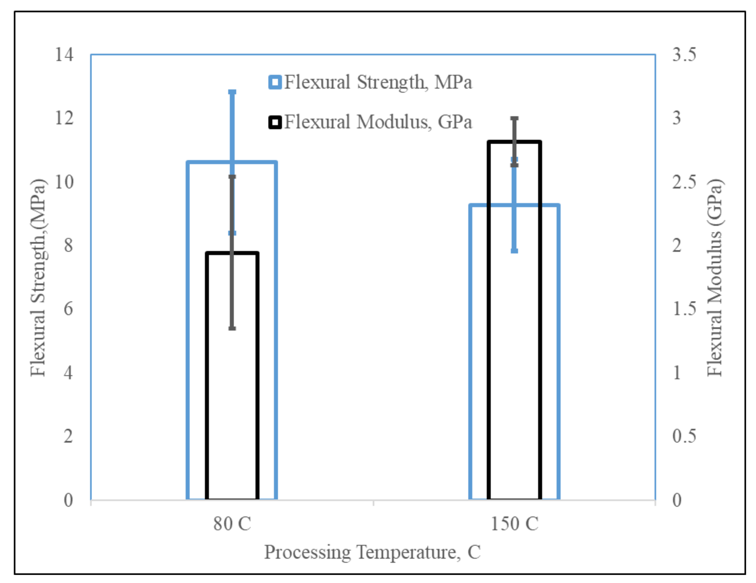
- Compressive testing
  - C1101 Instron Load frame
  - Crosshead speed- 1mm/min
- Compressive Strength, $S = \frac{Fmax \times 4}{\pi D^2}$
- Flexure testing
  - C1102 Instron Load frame
  - Crosshead speed- 1mm/min
  - 4x15x50 mm
  - Span length 40 mm
  - ASTM C D 790
- Flexural Strength, $S_b = \frac{3FL}{2bw^2}$

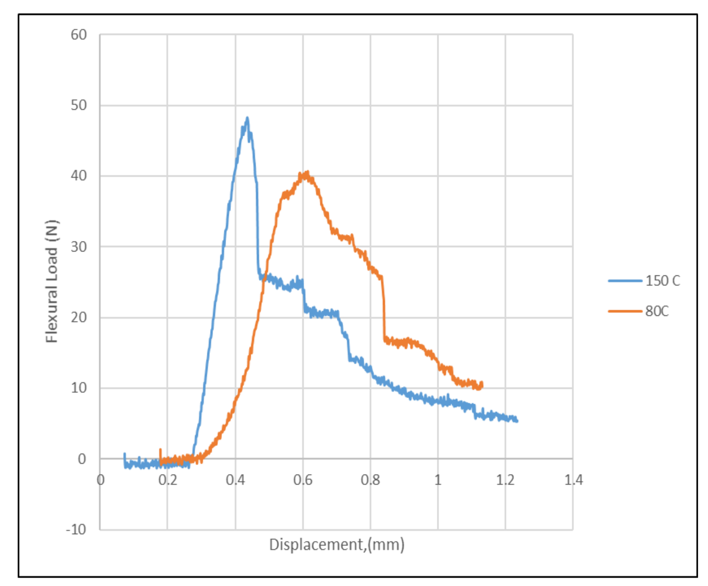


Fig(6) FAGP Compressive Strength (MPa) at 80°C



Fig(7)Flexural Test at 80°C and 150°C





Fig(8)Variations in Flexural Strength and Modulus