Structural Composites for High-Temperature Applications

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Abstract

Composite materials are generally designed in a certain combination with more than one constituents in order to meet a specific goal as defined in terms of chemical, physical or mechanical properties. Ceramic matrix composites (CMC) are one of the fastest growing material in the field of materials science. The current Research aims at developing eco-friendly ceramic matrix composites for Bio medical and high temperature applications.

Introduction

Geopolymer is a low temperature curable inorganic polymer which has potential in high temperature applications. Geopolymer based materials are developed from recyclable earth's crust including Fly ashes and Kaolin. These materials can be treated and processed under eco-friendly processing method in order to obtain valuable alternatives to conventional ceramic materials for high temperature composites. Selecting proper activators and activator-to-precursor ratio are crucial for optimum geopolymer properties. Combining with pozzolanic material like Coal ash or Rice husk ash help binding the aggregates and provide hardened and strong materials. Nano materials are considered as the filler and toughening agent of the geopolymer systems. Nano reinforcement can be performed using several nanomaterials including Fumed Silica, Silicon Carbide whiskers and Rice husk ash based Silica.

Methods

In this project Metakaolin-Potassium (MK-K GP) Geopolymer was prepared using heat treated Kaolin , Potassium silicate with a poly-condensation reaction in Alkaline medium. Molds were prepared for sample fabrication in variety of characterizations. 3D printed plastics and curable silicones were used in order to create flexible compression and tensile samples. Those characterization techniques were utilized in order to understand the underlying chemical, physical and mechanical behavior of Geopolymer binder and compare the results with Ordinary Portland cement (OPC).

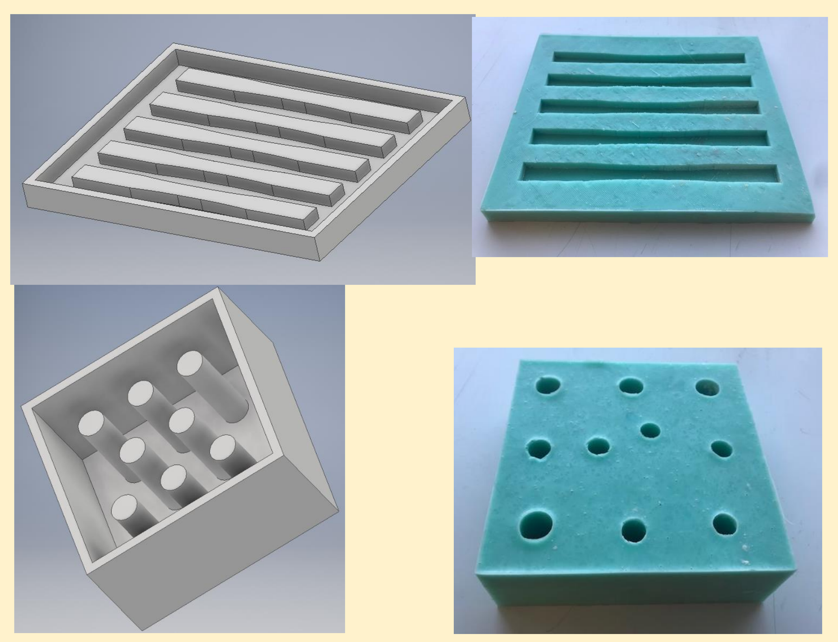

Figure1: Mold Designs and silicones

Acknowledgements

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References

- Akm S. Rahman and Donald W. Radford. "Evaluation of the geopolymer /nanofiber interfacial bond strength and their effects on model fracture toughness of geopolymer matrix at high temperature". Composite Interfaces (2017). Informa UK Limited, trading as Taylor and Francis Group 2017.
- Samsur Rahman and Donald W. Radford. "Inorganic polymer matrix material processing optimization". SAMPE technical conference proceedings. Wichita, KS, October 21-24,2013. Society for Advancement of Material and Process Engineering.

Results

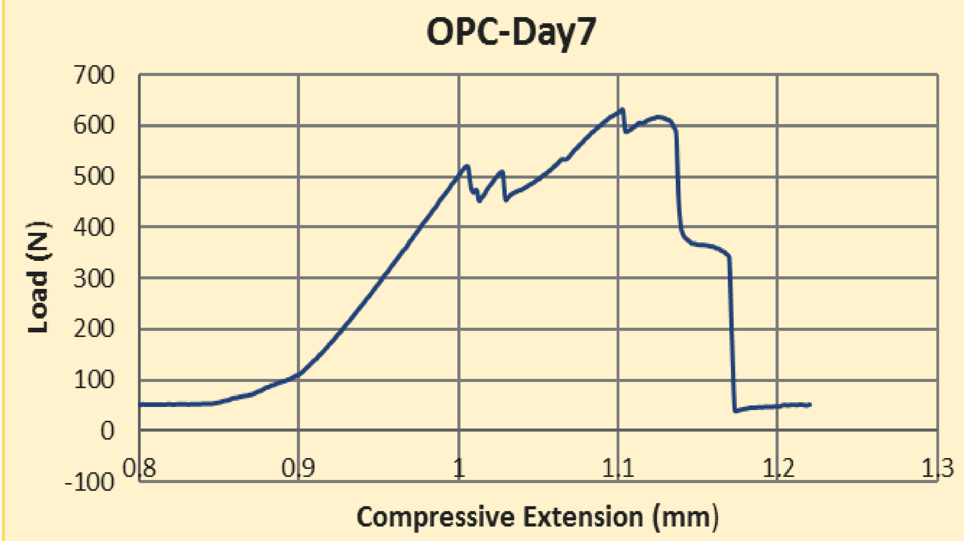

Figure 2(a) Compressive test of OPC at 7 day cure

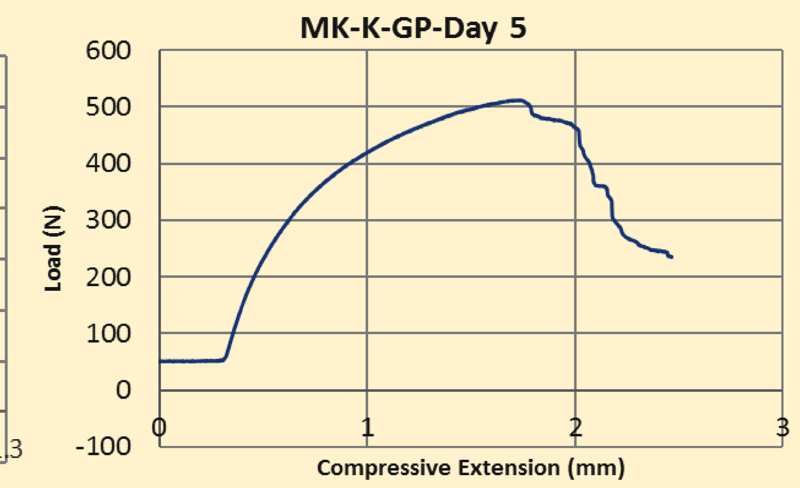

Figure 2(b) Compressive test of MK_K_GP at 5 day cure

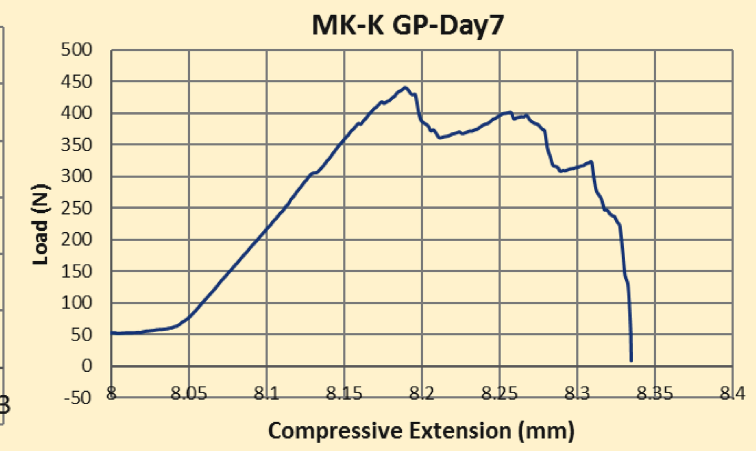

Figure 2(c) Compressive test of MK-K GP at 7 day cure

Compression load vs deflection of OPC and MK-K GP at 5 and 7 day are presented in Figure 2. Compressive OPC and MK-K GP samples are presented in Figure 3. The graph is prepared by the average Strength of 3 samples at each curing days, Ordinary Portland cement at 7 days curing and Meta kaolin geopolymer at 5 and 7 curing days. The strength of MK-K GP is almost equal to that of OPC at 7 day curing period. Also the strength of MK-K increased with curing time.

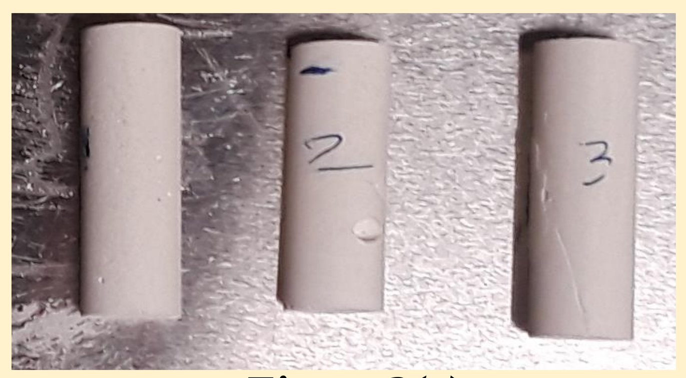

Figure 3(a):
Ordinary Portland Cement (OPC)

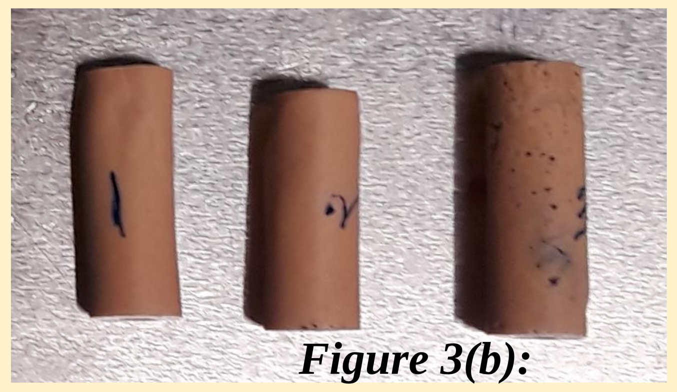

Figure 3(b):
Meta Kaolin potassium Geopolymer (MKK-GP)

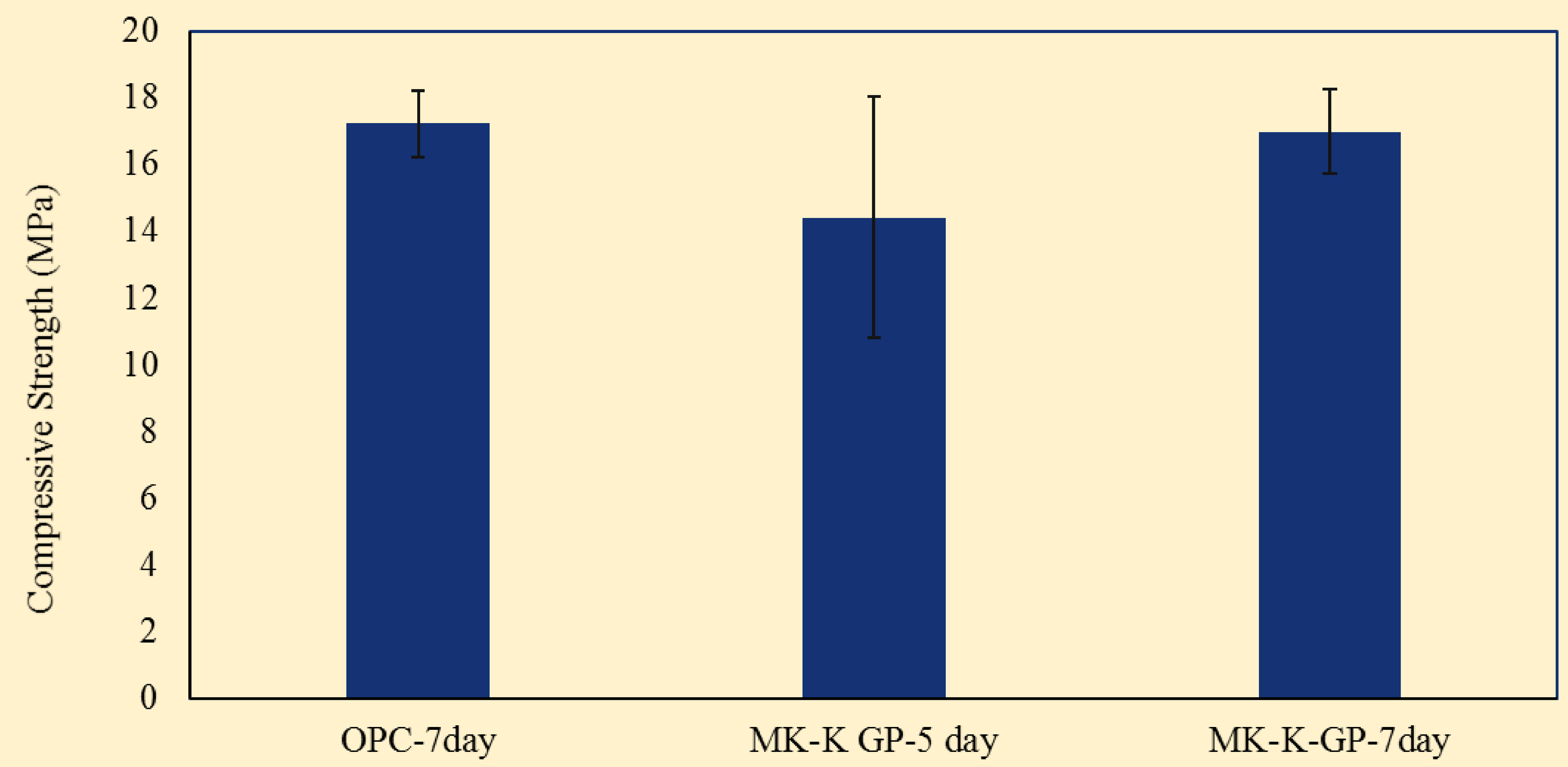

Figure 4. Compressive Strengths of Ordinary Portland Cement and MK-K Geopolymer at various curing time

Conclusions

It is obvious that, as the curing time increases, the plasticity of MK-K GP disappears and the brittle nature increases, and simultaneously the strength increases. The strength increase results from the consolidation, increased chemical reactions and cross links. ,OPC has initial abrupt failure than MK-K-GP. Modulus of MK-K-GP's elasticity is higher than OPC's. In Addition, few bubbles were accumulated in both OPC and MK-K GP samples. Pre degasification and uniform particle size and pre-degasification of the slurry may help reducing the bubbles. In the next phase of the project, few other material combination and better processing technique will be implemented. MK-K-GP may have potential to dental and bone implant and bio-medical field. Further analysis is required to clearly understand the evolution of strength of Geopolymer as a function of composition and processing parameters.