IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 6.252

Volume 2, Issue 8, May 2022

Results Analysis of the Synergistic Effects of Copper Slag and Rice Husk Ash in Geopolymer Concrete

Indarpal Singh Dhariwal[1] **and Raushan Kumar**[2]
Research Scholar, Department of Civil Engineering[1]
Assistant Professor, Department of Computer Science and Engineering[2]
Eklavya University, Damoh M.P, India

Abstract: *Since unreinforced masonry (URM) constructions are susceptible to earthquakes, methods and materials for reinforcing and restoring them need to be developed. Nevertheless, several of the current URM retrofitting methods' materials and the waste they produce at the end of their useful lives are not sustainable. Environmental issues have persisted as a result of the massive global carbon footprint caused by the production of ordinary Portland cement (OPC). Geopolymers, which are more environmentally benign and sustainable than PPC, offer a viable replacement for OPC in these issues. In engineering cementitious composites (ECC), geopolymers can take the place of the OPC component, which is advised in order to reinforce and repair URM structures. The most recent advancements in our understanding of the use of geopolymers in URM constructions are covered in this publication.*

Keywords: Ordinary Portland Cement, Geopolymer, Engineering Cementitious Composites, Unrein-Forced Masonry, Strengthening; Restoration

I. INTRODUCTION

Ordinary Portland cement (OPC), a crucial component of concrete, has been demonstrated to substantially increase greenhouse gas emissions in the atmosphere. Concrete is widely used in our expanding urban landscape. One way to get around this issue is to swap out OPC with environmentally acceptable and sustainable substitutes that have comparable strength and ability restoration values. Geopolymers are currently being researched in great detail as an OPC substitute. According to Saloni et al, geopolymers are sustainable materials since they use less energy when made from industrial byproducts. Replacing OPC, which requires a significant amount of energy to make, might also lessen market dominance in the early 20th century. The components of masonry structures include cast stone, clay, concrete, natural stone, terra cotta, adobe, and pisé de placed in a mortar, terre, cobb. These materials are only meant to endure compression loads because they have a low tensile strength. Crushing, buckling, and brittle failure rank among the most frequent reasons why masonry constructions fail, according to ICOMOS (2003). Due to its poor tensile capacity, unreinforced masonry buildings are susceptible to earthquake-induced loads, such as lateral loads that occur in-plane or eccentric loads that occur out-of-plane. These loads can result in diagonal fissures, wall rotation, or sliding. According to recent studies, masonry walls should be strengthened against both in-plane and out-of-plane loads by using engineered cementitious composites (ECC), such as fibre- and fabric-reinforced cementitious composites. The OPC of these ECC can be swapped out for geopolymers to make the material more environmentally friendly and sustainable. Additionally, Since geopolymers are said to have more mechanical strength and endurance than OPC-based ECC, ECC can be improved. In spite of this, geopolymers have not extensively taken the place of OPC in fortifying and re-establishing URMs. Aesthetic qualities, workability, thixotropic behaviour, and chemical interaction with the substrate are some of the factors that are yet unknown when it comes to utilisation as a restorative material. However, studies on fiber-reinforced composites based on geopolymers have solely focused on grouts; geopolymers can also be used as strengthening materials for URMs in deep repointing, jacketing, and cement-plastering.

II. GEOPOLYMER CHARACTERIZATION METHODS

(i) Fourier Transform Infrared Radiation (FT-IR) Spectroscopy- According to Yu et al, FT-IR spectroscopy is a technique that offers a bulk study of the raw materials' molecule adsorption bands and the alterations that have taken place during product production. The FT-IR bands seen in fly-ash-based geopolymer (GPC) and regular Portland cement (OPC) concretes were identified by Pasupathy et al. big bands in GPC concrete include 785, 946, 1152, 1313, and 1635 cm−1, while big bands in OPC concrete are 856, 965, 1062, 1116, 1289, 1363, 1511, and 2948 cm−1. Furthermore, the Si–O–Al/Si band in GPC is located at 946 cm−1, while in OPC it is found at 965 cm−1. Figure 1 shows that O-H bending vibrations are detected at 1313, 1635, and 785 cm−1 in GPC and OPC, respectively. According to Chen et al, the Reactive ultrafine fly ash (RUFA)-based geopolymer showed FT-IR bands that were in line with previous research. The presence of water molecules in the sample is confirmed by the absorption bands at 1650 cm−1 and 3480 cm−1, which represent the bending vibrations of H–O–H and –OH. The in-plane bending vibration of Si–O–Si is located at 460 cm−1, while the presence of Si–O–Al bending vibration is shown by the band at 728 cm−1. Following alkali activation, the band moved to 1044 cm−1, 1026 cm−1, 1009 cm−1, and 1002 cm−1 at 1093 cm–1 of fly ash. This phenomenon is explained by either an increase in the amount of Al substituents in the geopolymer or an increase in the number of silicon sites with nonbridging oxygen.

(ii) Scanning Electron Microscopy with Energy-Dispersive Spectroscopy (SEM-EDS)- SEM examination was described as a technique to validate the formation of the gel phase and examine the particle surface morphology of the produced material and raw material by Lee and van Deventer and Sasui et al. However, EDS analysis either validates the presence of certain elements like Si, Al, Mg, O, and Na or provides an elemental analysis (area or point) of the created material. SEM was utilised by Eliche-Quesada et al. to examine how the geopolymerization procedure affected the microstructures of the geopolymers. Hydrated sodium aluminosilicate gel (Na-A-S-H) is shown to form in the control sample. In addition, adding various kinds of clay to the geopolymer produced a C-A-S-H or Ca-Na-S-H.

(iii) Brunauer–Emmett–Teller (BET) Method- The Brunaeur–Emmett–Teller method, also known as the BET method, is used to calculate the surface area (m2g−1) of materials and then link that surface area with the materials' mechanical and chemical properties. Because geopolymerization works better with smaller particles, Güngör and Özen came to the conclusion that the compressive strength of the geopolymer mortars increased with surface area. The surface area of the raw materials and the final geopolymers composed of red mud and coal gangue were measured by Wang et al. The surface area of samples is increased by geopolymerization and the addition of red mud Na2SiO3 as an activator, according to the researchers' observations. Larger samples exhibit improved adsorption.

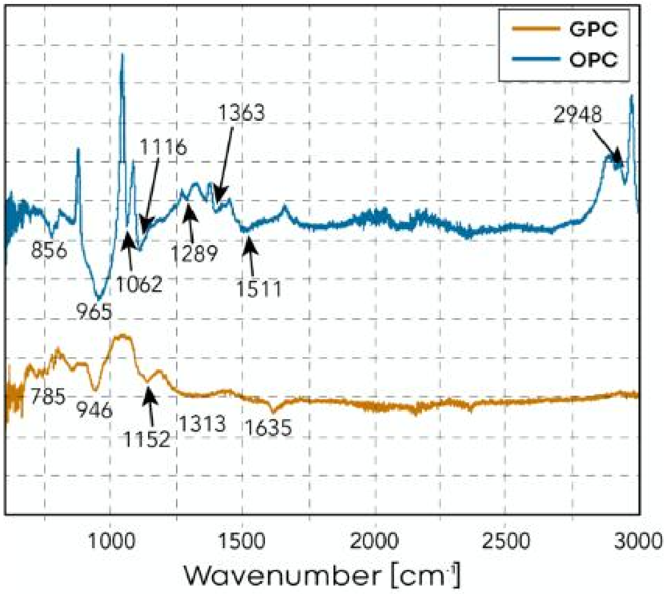

Figure 1- FT–IR peaks observed in fly-ash-based GPC and OPC samples

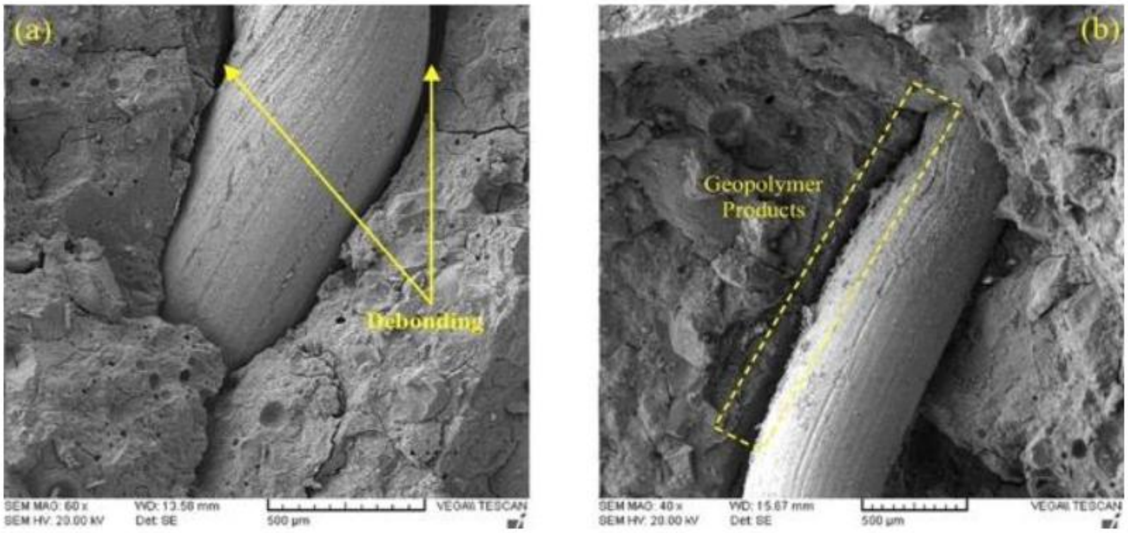

Figure 2- SEM images of uncoated steel fiber matrix transition zone. Debonding at the interface (a) and geopolymeric products on the surface of steel fiber (b)

III. RESULTS AND DISCUSSION

The Guadua angustifolia fibres' FTIR analysis results are displayed in Figure 3. Following a 24-hour immersion treatment in Ca(OH)2, 3 Molar, the functional groups found inside the fibres were revealed. Eliminating chemical and biological contaminants that impacted the concrete mixtures' quality was the treatment's main goal. An amorphous phase is evident in the spectra (Figure 3), where a peak at 1021 cm−1 corresponds to the alteration of the chemical bonds associated with the C–O group. The asymmetric axial deformation of the C–O–C group in accordance with the peak at 1250 cm−1 characterises the features associated with low molecular weight polysaccharide compounds and would subsequently prove the loss of lignin. The Guadua angustifolia samples that had been chemically treated showed bands associated with crystalline cellulose, according to the FTIR analysis. Additionally, changes were seen in the bands that corresponded to the components of lignin and hemicellulose, suggesting that these materials had been removed or that their chemical interactions had been altered. The findings suggest that the specimens' absorption of moisture has decreased. The crystalline phase is increasing and the water absorption capability is decreasing, as indicated by the bands at 1250 and 1506 cm−1. The alteration of the cellulose phases is the cause of the peak at 1638 cm−1. The hemicellulose's cetyl-esters' carbonyl groups (C=O) are responsible for the peak at 1730 cm−1. The peak is weak and is caused by the alkaline treatment of the lignocellulosic material with Ca(OH)2. The stretching of the -OH group, linked to the cellulose molecule's -OH bond alteration brought on by interactions with the Ca(OH)2 solution, is responsible for the band at 3358 cm−1. The presence of aldehydes, which comprise the solutions employed during infiltration, is shown by these final two bands. The FTIR spectra of the concrete without Guadua angustifolia fibres added is shown in Figure 4. Within the 400–900 cm−1 range, there are noticeable, tiny peaks that verify the establishment of a geopolymer network connecting Si and Al, connected by oxygen bridges resulting from hydration processes. A band at 1021 cm−1 corresponds to the partial substitution of aluminium for silicon as a result of the steel slag's composition and its 80% by weight addition to the mixture. The weak Al–O bond that forms as a result of the precursor dissolving during geopolymerization and then being reincorporated into the network, changing the bond's chemical environment, is indicated by the peak with the lowest intensity. The band at 1506 cm−1 that corresponds to the vibration is connected to the bonding of the carbonyl group as a result of the CaO concentration in the slag. This element and the concrete's mechanical qualities are connected. The bands located at 1638 and 1730 cm−1 are ascribed to the SiO4−2 reaction in the C–S–H bonds during the concrete's hydration process. The peak located at 2925 cm−1 signifies the existence of sodium hydroxide and water. The primary cause of the peak displacement below 3000 cm−1 is the elevated alkaline activator concentrations. The activator's reaction with the mixture's calcium sulphate is indicated by the peak at 3358 cm−1.

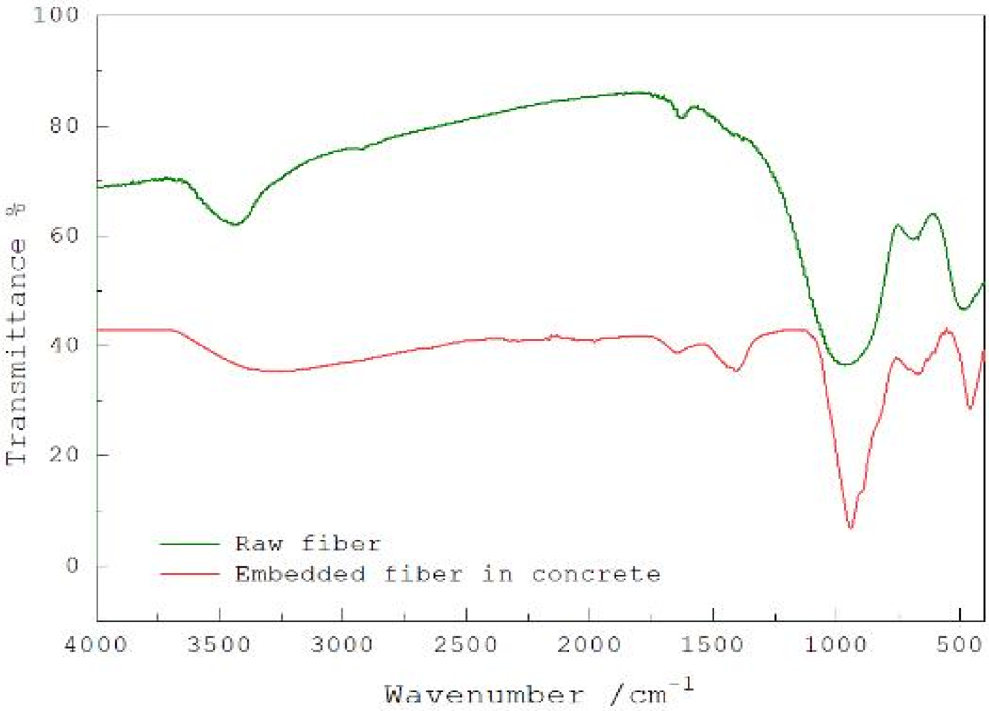

Figure 3- FTIR spectrum of Guadua angustifolia fibers

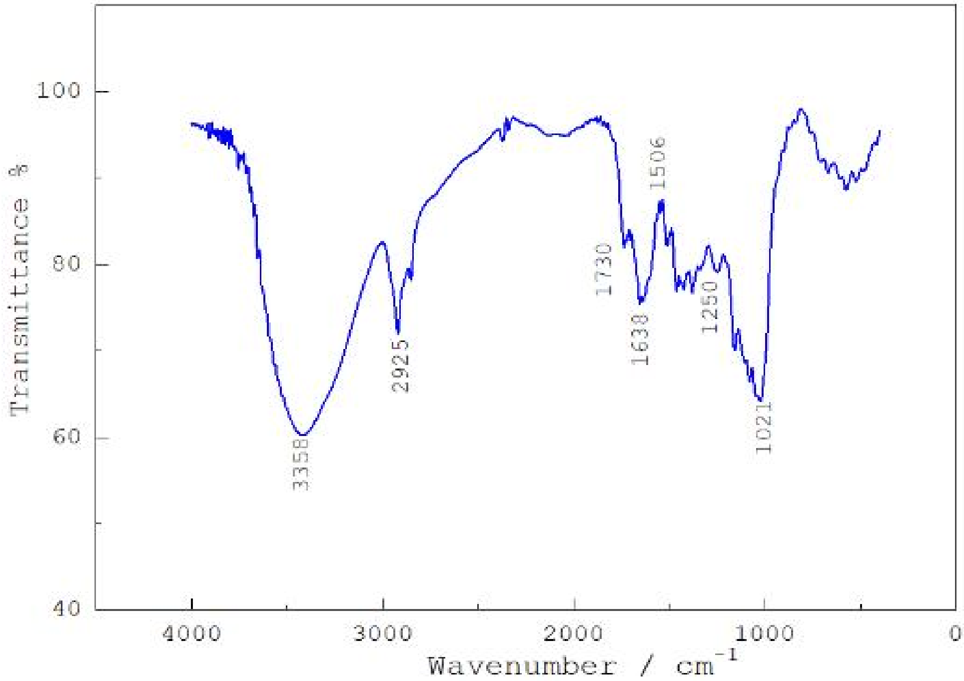

Figure 4- FTIR spectrum of concrete samples with added fly ash and steel slag, activated by rice husk ash

IV. CONCLUSION

The material guadua angustifolia is sustainable and renewable. From an environmental perspective, this makes it a desirable alternative. The use of conventional building materials, including steel, which have a greater negative impact on the environment, can be lessened by adding guadua fibres to alkaline-activated concrete. The cellulose content of the Guadua angustifolia fibres was determined by X-ray diffraction. Calcium silicate gels, calcium silicate hydrate (C-S-H), and other crystalline substances were identified as the hydration products using X-ray diffraction. When compared to concrete without reinforcement, the mixture including Guadua angustifolia fibres exhibited the best mechanical behaviour. The usage of Guadua angustifolia's mechanical qualities along with the advantages of the constituent materials is established by incorporating Guadua fibres into ternary mixes. Because of the hydraulic character of the slag and the gradual pozzolanic reaction of the fly ash, tensile and flexural strength improve at ages older than 28 days. These properties were found via FTIR.

REFERENCES

[1]. Mahasenan, N.; Smith, S.; Humphreys, K. The Cement Industry and Global Climate Change Current and Potential Future Cement Industry CO2 Emissions. In Proceedings of the Greenhouse Gas Control Technologies—6th International Conference, Kyoto, Japan, 1–4 October 2002; pp. 995–1000.

[2]. Pham, T.M.; Lim, Y.Y.; Pradhan, S.S.; Kumar, J. Performance of rice husk Ash-Based sustainable geopolymer concrete with Ultra-Fine slag and Corn cob ash. Constr. Build. Mater. 2021, 279, 122526.

[3]. Neupane, K.; Hadigheh, S.A. Sodium hydroxide-free geopolymer binder for prestressed concrete applications. Constr. Build. Mater. 2021, 293, 123397.

[4]. Ricciotti, L.; Molino, A.; Roviello, V.; Chianese, E.; Cennamo, P.; Roviello, G. Geopolymer Composites for Potential Applications in Cultural Heritage. Environments 2017, 4, 91.

[5]. ASTM C1713-17. Standard Specification for Mortars for the Repair of Historic Masonry; ASTM International: West Conshohocken, PA, USA, 2017.

[6]. ICOMOS. Recommendations for the Analysis and Restoration of Historical Structures; ISCARSAH, International Council on Monuments and Sites: Paris, France, 2003.

[7]. Ismail, N.; Ingham, J.M. In-plane and out-of-plane testing of unreinforced masonry walls strengthened using polymer textile reinforced mortar. Eng. Struct. 2016, 118, 167–177.

[8]. Meriggi, P.; de Felice, G.; De Santis, S. Design of the out-of-plane strengthening of masonry walls with fabric reinforced cementitious matrix composites. Constr. Build. Mater. 2020, 240, 117946.

[9]. Zhang, L.; Jia, Y.; Shu, H.; Zhang, L.; Lu, X.; Bai, F.; Zhao, Q.; Tian, D. The effect of basicity of modified ground granulated blast furnace slag on its denitration performance. J. Clean. Prod. 2021, 305, 126800.

[10]. Tober, M. PubMed, ScienceDirect, Scopus or Google Scholar—Which is the best search engine for an effective literature research in laser medicine? Med. Laser Appl. 2011, 26, 139–144.

[11]. John, M.J.; Anandjiwala, R.D. Recent developments in chemical modification and characterization of natural fiber-reinforced composites. Polym. Compos. 2021, 29, 187–207.