Chapter 8

Geopolymer Sourced with Fly Ash and Industrial Aluminum Waste for Sustainable Materials

Sujitra Onutai
Nagaoka University of Technology, Japan

Sirithan Jiemsirilers
Chulalongkorn University, Thailand

Takaomi Kobayashi
Nagaoka University of Technology, Japan

ABSTRACT

Geopolymer is alumino-silicate material which can apply for many applications due to that geopolymers have several attractive properties of high strength, low permeability, high acid resistance, hazardous materials, and immobilization of toxic materials. This chapter presents synthesis of the dense and the porous structures of geopolymer by using fly ash and industrial waste as the raw materials. Aluminum hydroxide waste (Al-waste) and fly ash (FA) were used to synthesis the dense geopolymers for cement materials. The Al-waste based geopolymer influenced the geopolymer strength, when sodium hydroxide (NaOH) concentration was changed at different curing temperatures. As preliminary microwave oven was exposed in the lower NaOH paste of geopolymer, the successful synthesis of geopolymer cement was obtained. In addition, porous fly ash geopolymers was achieved using a household microwave oven. The geopolymer paste was cured within 1 min by using a microwave oven at different output power. Porous geopolymers were formed immediately as ued at 850 W power of the microwave oven.

INTRODUCTION

Geopolymers are known as sustainable materials with eco-friendly process, since these simply can use wastes for raw materials, and have excellent mechanical properties (Kumar & Kumar, 2011; Nazari & Sanjayan, 2015). Usually, the geopolymer materials are activated in a high alkali solution (Davidovits,

DOI: 10.4018/978-1-5225-1971-3.ch008

2008) because alumino silicate geopolymers consist of tetrahedral AlO_4 and SiO_4 units that occur easily in a polycondensed polymer framework in high-alkali conditions (Davidovits, 1991). In geopolymer materials prepared at low temperatures with high alkali solutions, generally alumino-silicate materials such as slag (Karakoç et al., 2014), metakaolin (Rovnaník, 2010a), and fly ash (Ryu, Lee, Koh, & Chung, 2013) were mixed with alkaline solution. For example, sodium or potassium hydroxide is necessary for dissolving silicon and aluminium atoms from raw materials of natural minerals or industrial waste. The silicate alkaline solution includes:

- A binder,
- Alkaline activator, and
- A dispersant or plasticizer (Abdullah, Jamaludin, et al., 2012a; Nazari, Bagheri, & Riahi, 2011; Somna, Jaturapitakkul, Kajitvichyanukul, & Chindaprasirt, 2011).

The basic forms of the chemical structure have silicon-aluminate 3D structures with cross-linked chain bonds together in the geopolymer matrix (Songpiriyakij, Kubprasit, Jaturapitakkul, & Chindaprasirt, 2010). The condensation reaction of geopolymers proceeded greatly at room temperature (Puertas, Martínez-Ramírez, Alonso, & Vázquez, 2000). At elevated temperatures of 40–95 °C, geopolymerization is improved in the strength of specimens (Bakharev, 2005; Chindaprasirt, Chareerat, & Sirivivatnanon, 2007; Panias, Giannopoulou, & Perraki, 2007; Swanepoel & Strydom, 2002). Dense geopolymer materials having apparent density higher than 1 g/cm^3 were applied for construction materials (Andini et al., 2008). Several reports described the use of metakaolin and fly ash as starting materials in geopolymerization (Duxson, Fernández-Jiménez, Lukey, et al., 2007; Komnitsas & Zaharaki, 2007). Moreover, industrial wastes of various types were used to synthesize geopolymers materials such as:

- Aluminum slag,
- Grey cast iron slag, and
- Blast furnace slag.

Among them, the use of etching surface waste, aluminum hydroxide, is interesting in the raw material for geopolymers. The Al-waste has high aluminum contents, making it suitable for the synthesis of better Al-source of geopolymers. Therefore, it is extremely attractive to investigate the geopolymerization of fly ash and Al-waste as a sustainable source for cement substitute materials.

In contrast, foam geopolymers were synthesized in high- or low-temperature processing conditions for widely diverse applications such as in carriers of catalyzer, adsorbents, sensors, hot gas filters, solid–liquid separation processes, and thermal insulators (López, Sugita, & Kobayashi, 2014a; Strozi Cilla, Raymundo Morelli, & Colombo, 2014; Studart, Gonzenbach, Tervoort, & Gauckler, 2006; H. Wang, Li, Wang, & Yan, 2015). In high-temperature processing, the raw materials and foaming agents (aluminium powder or hydrogen peroxide) were mixed with silica fume in situ foaming techniques. After geopolymerization, the geopolymer sample was sintered at 1000-1200 °C to produce in the high strength of porous geopolymer (Abdullah, Jamaludin, et al., 2012b). Moreover, a low temperature process achieved geopolymerization in an alkaline environment with a foaming agent for the decomposed into the water and oxygen. In this case, aluminium and silicon in fumed silica also initiated the release of hydrogen gas, leading to a porous structure. Porous geopolymer was cured in a conventional oven at 40-70 °C for 24–48 h in a long curing period (Böke, Birch, Nyale, & Petrik, 2015; Masi, Rickard, Vickers, Bignozzi,

19 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/geopolymer-sourced-with-fly-ash-and-industrial-aluminum-waste-for-sustainable-materials/173858

Related Content

Numerical Analysis of the Fluid Flow Behavior in the Plain Journal Bearing at Textured and Not Textured Surface

Bendaoud Nadiaand Mehala Kadda (2021). *International Journal of Surface Engineering and Interdisciplinary Materials Science (pp. 40-59).*

www.irma-international.org/article/numerical-analysis-of-the-fluid-flow-behavior-in-the-plain-journal-bearing-at-textured-and-not-textured-surface/267211

Investigating Bauschinger Effect and Plastic Hardening Characteristics of Sheet Metal under Cyclic Loading

Jasri Mohamad (2017). *International Journal of Materials Forming and Machining Processes (pp. 1-14).*

www.irma-international.org/article/investigating-bauschinger-effect-and-plastic-hardening-characteristics-of-sheet-metal-under-cyclic-loading/189059

Experimental Investigations on Thermo-Hydraulic Performance of TIO2/Water Nanofluids in a Flat Tube

Anish Sihag, Neeti Arora, Munish Guptaand Puneet Katyal (2025). *Tools, Techniques, and Advancements in Engineering Materials Science (pp. 167-182).*

www.irma-international.org/chapter/experimental-investigations-on-thermo-hydraulic-performance-of-tio2water-nanofluids-in-a-flat-tube/366820

Frictional Behavior of Aluminium MMC Foam Synthesized Using Dual Foaming Agent

Shamim Haidar, Mukandar Sekh, Joyjeet Ghoseand Goutam Sutradhar (2017). *International Journal of Surface Engineering and Interdisciplinary Materials Science (pp. 18-32).*

www.irma-international.org/article/frictional-behavior-of-aluminium-mmc-foam-synthesized-using-dual-foaming-agent/192112

Cloud Based 3D Printing Business Modeling in the Digital Economy

Norman Gwangwava, Albert U. Ude, Enock Ogunmuyiwaand Richard Addo-Tenkorang (2020). *Additive Manufacturing: Breakthroughs in Research and Practice (pp. 116-135).*

www.irma-international.org/chapter/cloud-based-3d-printing-business-modeling-in-the-digital-economy/232925