Advanced Powder Technology xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Advanced Powder Technology

journal homepage: www.elsevier.com/locate/apt

Rapid Communication

A novel water permeable geopolymer with high strength and high permeability coefficient derived from fly ash, slag and metakaolin

Ping Duan *, Chunjie Yan, Wei Zhou

Faculty of Materials Science and Chemistry, China University of Geosciences, Wuhan 430074, China
Engineering Research Center of Nano-Geomaterials of Ministry of Education, China University of Geosciences, Wuhan 430074, China

ARTICLE INFO

Article history:
Received 3 January 2017
Accepted 10 March 2017
Available online xxxx

Keywords:
Geopolymer
Water permeable
Metakaolin
Permeability coefficient

ABSTRACT

In this work, a new water permeable geopolymer with high strength and high water permeability coefficient based on fly ash-slag-metakaolin was proposed. The experimental results show that fresh geopolymer composite exhibits dry characteristic and porous structure. The void ratio is 27.6% and the permeability coefficient reaches 1.70 cm/s. The compressive strength and flexural strength reach about 30 MPa and 6.2 MPa, respectively at 1 day and reach as high as 49 MPa and 11.3 MPa at 28 days of curing, respectively. After 100 freeze-thaw cycles, the terminal remaining mass is still larger than 80% along with internal damages and deteriorations on geopolymer paste coating. The dense microstructure of geopolymer matrix and interfacial transition zone indicates the high compressive strength, flexural strength and high freeze-thaw resistance of water permeable geopolymer.

1. Introduction

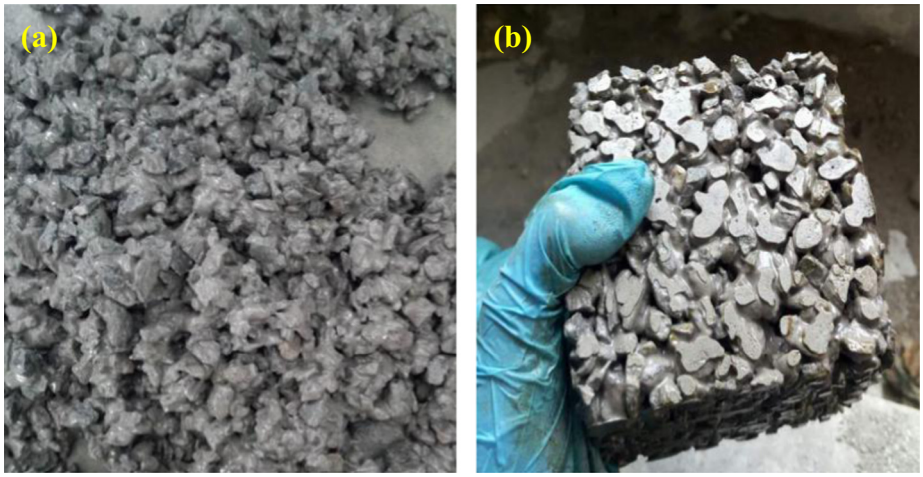
Water permeable concrete is an environmental-friendly material mainly consisting of cementitious binders, water and coarse aggregate. Use of water permeable concrete possesses several advantages including storm-water management, reduced pavement noise and pollutant control [1]. Traditionally, cement is used as the main cementitious material, however, the main drawbacks of cement including CO_2 emission and a vast amount of energy requirement [2,3] prompt various researches in an attempt to develop alternative materials to produce a new kind of concrete to combat these issues. Geopolymer is such an alternative material, it is eco-friendly and sustainable material with low carbon footprint and it is obtained from the polycondensation of aluminosilicate solids, activated by an aqueous solution of alkali silicate [4]. Geopolymer has several advantages when compared to ordinary Portland cement (OPC) including higher compressive strength, higher flexural strength, faster setting time, earlier strength development, lower CO_2 emissions, and higher temperature resistance [5–9].

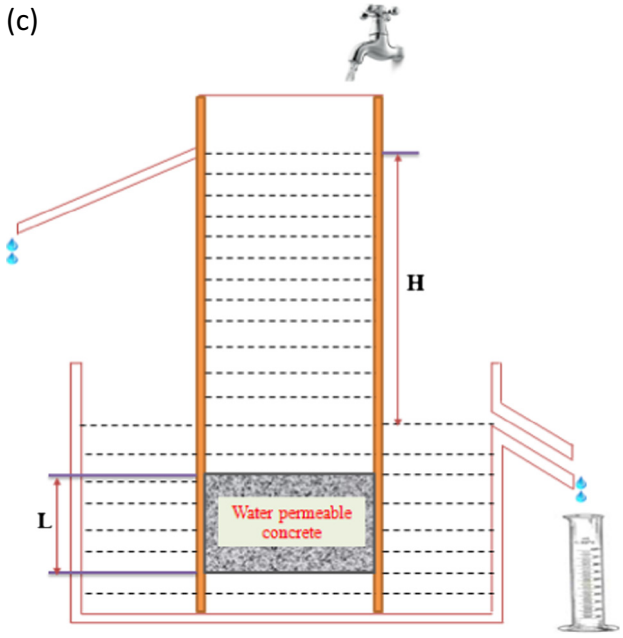
The previously reported findings mainly focused on cement based water permeable concrete. Kim et al. [1] prepared permeable concrete mixed with various alternative construction materials such as fly ash, fibers and tire chips. Huang et al. [10] developed a mathematical model for predicting water quality performance for different types of permeable pavements. Brunetti et al. [11] also discussed the suitability of a mechanistic model to describe the hydraulic behavior of permeable pavement. Park et al. [12] investigated the physical and mechanical properties as well as seawater purification characteristics of water permeable concrete using recycled aggregate. However, after reviewing the previously published findings, there is a lack of experimental data on gopolymer based water permeable concrete. The properties of water permeable concrete derived from geopolymer are not well-known, and little information is available about geopolymer based on fly ash, slag and metakaolin. Quantitative information on fly ash-slag-metakaolin geopolymer water permeable concrete still requires further investigation.

In order to reduce CO_2 emission and energy requirement, relieve the pressure from storm-water management and enlarge the utilization of industrial by-products, new water permeable geopolymer with high strength and high water permeability coefficient is urgently needed. In this work, a new water permeable geopolymer concrete with high strength and high water permeability coefficient based on fly ash, slag and metakaolin was developed.

* Corresponding author at: Faculty of Materials Science and Chemistry, China University of Geosciences, Wuhan 430074, China. Fax: +86 27 67885098.
E-mail addresses: dp19851128@sina.com, duanping@cug.edu.cn (P. Duan).

http://dx.doi.org/10.1016/j.apt.2017.03.009
0921-8831/





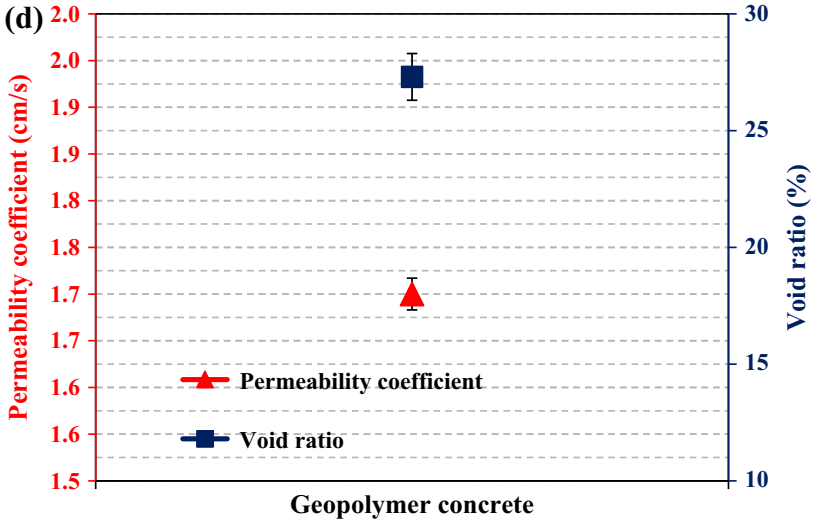


Fig. 1. Fresh geopolymer concrete mix (a), geopolymer concrete specimen (b); test device for permeability coefficient (c) and permeability coefficient and void ratio (d).

Please cite this article in press as: P. Duan et al., A novel water permeable geopolymer with high strength and high permeability coefficient derived from fly ash, slag and metakaolin, Advanced Powder Technology (2017), http://dx.doi.org/10.1016/j.apt.2017.03.009